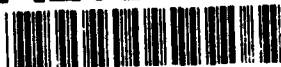


DTIC

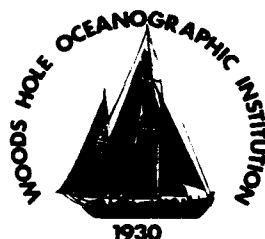
AD-A252 083



1

Technical Memorandum WHOI-2-84

Woods Hole Oceanographic Institution



DTIC
ELECTE
JUN 18 1992
S A D

Technical Memorandum No. 2-84

A Bibliography of References in Natural Water Photochemistry

Oliver C. Zafiriou

December 1984

92-15449



This document has been approved
for public release and sale; its
distribution is unlimited.

92 6 12 077

A BIBLIOGRAPHY OF REFERENCES IN
NATURAL WATER PHOTOCHEMISTRY

Oliver C. Zafiriou

TECHNICAL MEMORANDUM 02-84



Accession For	
NTIS CRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

Funding was provided by the NATO grant and by
the U. S. National Science Foundation under Grant OCE-83-15614.

TABLE OF CONTENTS

	<u>Page No.</u>
FORWARD	i
ACKNOWLEDGEMENTS	ii
BIBLIOGRAPHY	
I. Reviews and General References	1-4
II. Air-Water Interface	5-6
III. Direct Photolysis--Organic and Inorganic	7-12
IV. Heterogeneous Processes	13-17
V. Hydrogen Peroxide, Organic Peroxides, and Ozone	18-20
VI. Light and Underwater Light	21-25
VII. Petroleum	26-31
VIII. Photobiological Aspects	32-36
IX. Radicals	37-41
X. Singlet Oxygen	42-43
XI. Unknown Chromophores, Energy Transfer	44-51

FORWARD

This bibliography is intended as a useful complement to the critical review article resulting from the 1983 NATO ARI on "Photochemistry of Natural Waters" held at Woods Hole, MA, 12-16 September 1983. The bibliography supplements the short reference list in that article.

The references included here are organized in broad topics, roughly those covered in the ARI itself, plus a group of general references and reviews. The sources for these references are the published literature and the more available and substantive "grey literature" references cited by:

- (1) The NATO ARI Extended Abstracts
- (2) The NATO ARI Rapporteur's Reports.
- (3) Several previous review articles.

The bibliography includes most of the relevant literature in the period 1970-1983, with sketchy coverage before and after those dates. Also, the coverage of the literature is particularly uneven in

- (1) Non-English languages (especially Russian and Japanese)
- (2) Xenobiotic photochemistry
- (3) Petroleum photochemistry.

The symbols after the authors' names indicate how the citation was checked for accuracy. References indicated by * have been checked against the original source. References indicated by ** were checked by telephone or letter. References indicated by † were checked against a computerized data-base. Unmarked citations are taken as given by secondary sources; we cannot attest to their completeness/accuracy citations are taken as given by secondary sources.

ACKNOWLEDGEMENTS

It is appropriate to thank the NATO ARI participants and rapporteurs for their inputs, the backbone of this bibliography. Additionally, I thank Marilyn R. Hess for preparing and organizing this document, and Colleen Hurter and Mary B. True for library research and other assistance. Without the help of all three, this useful but tedious task would have been impossible.

The preparation of this bibliography was funded by the NATO grant and by NSF Grant OCE-83-15614.

I. REVIEWS AND GENERAL REFERENCES

- Adamson, A. W. and Fleischauer, P. D. (eds.), 1975.* "Concepts of Inorganic Photochemistry," Wiley-Interscience, N.Y., 439 pp.
- Allen, A. O. and Bielski, B. H. J., 1982.* Formation and disappearance of superoxide radicals in aqueous solutions. In "Superoxide Dismutase" Vol. I (L. W. Oberley, ed.), CRC Press, Boca Raton, FL., pp. 125-141.
- Balzani, V. and Carassiti, V., 1970.† "Photochemistry of Coordination Compounds," Academic Press, N.Y., 432 pp.
- Benson, S. W., 1968.† "Thermochemical Kinetics; Methods for the Estimation of Thermochemical Data and Rate Parameters" (John Wiley and Sons, N.Y.), 223 pp.
- Calkins, J. (ed.), 1982.* "The Role of Solar Ultraviolet Radiation in Marine Ecosystems" (Plenum Press, N.Y.), 724 pp.
- Cowan, D. O. and Drisko, R. L., 1976.* "Elements of Organic Photochemistry." Plenum Press, N.Y., 586 pp.
- Fallab, S., 1967.* Reactions with molecular oxygen. Angew. Chem. Internat. Edit. 6(6): 496-507.
- Faust, S. D., 1975.* Nonbiological degradation and transformations of organic pesticides in aqueous systems. In "Marine Chemistry in the Coastal Environment" (T. M. Church, ed.), A.C.S. Symp. Ser. 18. Am. Chem. Soc., Washington, D.C., pp. 572-595.
- Fridovich, I., 1982.* Measuring the activity of superoxide dismutases: an embarrassment of riches. In "Superoxide Dismutase," Vol. I (L. W. Oberley, ed.), CRC Press, Boca Raton, FL, pp. 69-77.
- Gäb, S., Schmitzer, J., Thamm, H. W., Parlar, H. and Korte, F., 1977.* Photomineralisation rate of organic compounds adsorbed on particulate matter. Nature 270: 331-333.
- Gorman, A. A. and Rodgers, M. A. J., 1981.* Singlet molecular oxygen. Chem. Soc. Rev. 10: 205-231.
- Jagger, J., 1981.* The expanding science of photobiology. Nature 289: 636-637.
- Jerlov, N. G., 1968.* "Optical Oceanography," Elsevier Oceanography Series, Vol. 5 (Elsevier, Amsterdam), 194 pp.
- Jerlov, N. G., 1976.* "Marine Optics" (Elsevier Sci. Pub., N.Y.), 231 pp.

- Kearns, D. R., 1971.* Physical and chemical properties of singlet molecular oxygen. Chem. Reviews 71: 395-427.
- Kochi, J. K., ed., 1973.* "Free Radicals" (Wiley-Interscience, N.Y.), 713 pp.
- Kotzias, D., Klein, W., Lotz, F., Nitz, S. and Korte, F., 1979.* Zur photo-induzierten mineralisierung organischer chemikalien. Chemosphere 5: 301-304.
- Lal, D., 1977.* The oceanic microcosm of particles. Science 198: 997-1009.
- Lemaire, J., Campbell, I., Hulpke, H., Guth, J. A., Merz, W., Philp, J. and von Waldow, C., 1982.* An assessment of test methods for photodegradation of chemicals in the environment. Chemosphere 11: 119-164.
- MacIntyre, F., 1974.* The top millimeter of the ocean. Scient. Amer. 230: 62-77.
- Mantoura, R. F. C., 1981.* Organo-metallic interactions in natural waters. In "Marine Organic Chemistry" (E. K. Duursma and R. Dawson, eds.), Elsevier, Amsterdam, pp. 179-223.
- Miller, S., 1983.* Photochemistry of natural water systems. Environ. Sci. Technol. 17(12): 568A-570A.
- Morel, F. M. M. and Morel-Laurens, N. M. L., 1983.* Trace metals and plankton in the oceans: Facts and speculations. In "Trace Metals in Sea Water" (C. S. Wong, E. Boyle, K. W. Bruland, J. D. Burton and E. D. Goldberg, eds.), NATO Conference Series #IV: Marine Chemistry, Plenum Press, N.Y., pp. 841-869.
- Neff, J. M., 1979.† "Polycyclic Aromatic Hydrocarbons in the Aquatic Environment: Sources, Fates and Biological Effects." Applied Science Publishers, London, 262 pp.
- Newman, L. (ed.), 1984.* "Gas-Liquid Chemistry of Natural Waters," Vols. 1 and 2 (Brookhaven National Laboratory, Upton, N.Y.).
- Nozik, A. J., 1980.* Introductory lecture: Photoelectrochemistry. Faraday Discussions, Chem. Soc., No. 70, pp. 7-17.
- Parsons, T. R., 1975.* Particulate organic carbon in the sea. In "Chemical Oceanography," Vol. 2, 2nd edition (J. P. Riley and G. Skirrow, eds.), Academic Press, N.Y., pp. 365-383.

- Payne, J., 1984.[†] Physical/chemical weathering of petroleum in the marine environment. Mar. Technol. Soc. Jour., in press.
- Pryor, W. A., 1956. "Free Radicals" (McGraw-Hill Book Company, N.Y.).
- Pryor, W. A. (ed.), 1976.* "Free Radicals in Biology," Vol. I, Academic Press, N.Y., 320 pp.
- Pryor, W. A. (ed.), 1976.* "Free Radicals in Biology," Vol. II, Academic Press, N.Y., 320 pp.
- Pryor, W. A. (ed.), 1977.* "Free Radicals in Biology," Vol. III, Academic Press, N.Y., 336 pp.
- Pryor, W. A. (ed.), 1980.* "Free Radicals in Biology," Vol. IV, Academic Press, N.Y., 384 pp.
- Pryor, W. A. (ed.), 1982.* "Free Radicals in Biology," Vol. V, Academic Press, N.Y., 304 pp.
- Robinson, N. (ed.), 1966.* "Solar Radiation" (Elsevier, Amsterdam), 347 pp.
- Safe, S. and Hutzinger, O., 1971.* Polychlorinated biphenyls: photolysis of 2,4,6,2',4',6'-hexachlorobiphenyl. Nature 232: 641-642.
- Schnitzer, M. and Khan, S. U., 1972.[†] "Humic Substances in the Environment" (Marcel Dekker, N.Y.), 327 pp.
- Sundström, G. and Ruzo, L. O., 1978.* Photochemical transformation of pollutants in water. In "Aquatic Pollutants: Transformation and Biological Effects" (O. Hutzinger, L. H. van Lelyveld and B. C. J. Zoeteman, eds.), Pergamon Press, N.Y., pp. 205-222.
- Swallow, A. J., 1980.* 6. Radiation Chemistry. In "Annual Reports C," The Royal Society of Chemistry, London, pp. 145-171.
- Turro, N. J., 1978.* "Modern Molecular Photochemistry," Benjamin/Cummings Publ. Co., Menlo Park, Calif., 628 pp.
- Walling, C., 1957.* "Free Radicals in Solution" (John Wiley and Sons, N.Y.), 631 pp.
- Williams, G. H. (ed.), 1965.[†] "Advances in Free Radical Chemistry" Vol. 1, Academic Press, NY.
- Williams, G. H. (ed.), 1965.[†] "Advances in Free Radical Chemistry" Vol. 2, Academic Press, NY., 274 pp.

- Williams, G. H. (ed.), 1969.[†] "Advances in Free Radical Chemistry" Vol. 3, Academic Press, NY., 317 pp.
- Williams, G. H. (ed.), 1972.[†] "Advances in Free Radical Chemistry" Vol. 4, Academic Press, NY., 307 pp.
- Williams, G. H. (ed.), 1975.[†] "Advances in Free Radical Chemistry" Vol. 5, Academic Press, NY., 394 pp.
- Worrest, R. C., 1982.* Review of literature concerning the impact of UV-B radiation upon marine organisms. In "The Role of Solar Ultraviolet Radiation in Marine Ecosystems" (J. Calkins, ed.), Plenum Press, N.Y., pp. 429-457.
- Zafiriou, O. C., 1977.* Marine organic photochemistry previewed. Mar. Chem. 5: 497-522.
- Zafiriou, O. C., 1983.* Natural water photochemistry. In "Chemical Oceanography," Vol. 8, 2nd ed. (J. P. Riley and R. Chester, eds.), Academic Press, London, pp. 339-379.
- Zafiriou, O. C., Jousset-Dubien, J., Zepp, R. G. and Zika, R. G., 1984. Natural water photochemistry. Environ. Sci. Technol. 18: 358A-371A.
- Zepp, R. G. and Baughman, G. L., 1978.* Prediction of photochemical transformation of pollutants in the aquatic environment. In "Aquatic Pollutants: Transformations and Biological Effects" (O. Hutzinger, I. H. van Lelyveld and B. C. J. Zoeteman, eds.) Pergamon Press, Oxford, pp. 237-263.
- Zepp, R. G., 1980.* Assessing the photochemistry of organic pollutants in aquatic environments. In "Dynamics, Exposure and Hazard Assessment of Toxic Chemicals" (R. Hague, ed.), Ann Arbor Science Publishers, Ann Arbor, Mich., pp. 69-110.
- Zepp, R. G., 1982.* Photochemical transformations induced by solar ultraviolet radiation in marine ecosystems. In "The Role of Solar Ultraviolet Radiation in Marine Ecosystems" (J. Calkins, ed.), Plenum Press, N.Y., pp. 293-307.
- Zika, R. G., 1977.* An investigation in marine photochemistry. Ph.D. thesis, Dalhousie University, Halifax, Nova Scotia.
- Zika, R. G., 1981.* Marine organic photochemistry. In "Marine Organic Chemistry: Evolution, composition, interactions and chemistry of organic matter in seawater" (E. K. Duursma and R. Dawson, eds.), Elsevier Sci. Publ. Co., Amsterdam, pp. 299-325.

II. AIR-WATER INTERFACE

- Baier, R. E., 1972.* Organic films on natural waters: Their retrieval, identification, and modes of elimination. J. Geophys. Res. **77**: 5062-5075.
- Barltrop, J. A. and Coyle, J. D., 1975.* "Excited States in Organic Chemistry" (John Wiley and Sons, N.Y.), 376 pp.
- Calvert, J. G. and Pitts, J. N. Jr., 1967.* "Photochemistry," John Wiley & Sons, N.Y., 899 pp.
- Chameides, W. L. and Davis, D., 1982.* The free radical chemistry of cloud droplets and its impact upon the composition of rain. J. Geophys. Res. **87**: 4863-4877.
- Ertel, J. R., 1978.* The Fate of Phytol in the Sea Surface Microlayer. MS thesis, Florida State University.
- Garland, J. A., Elzerman, A. W. and Penkett, S. A., 1980.* The mechanism for dry deposition of ozone to seawater surfaces. J. Geophys. Res. **85**(C12): 7488-7492.
- Gill, P. S., Graedel, T. E. and Weschler, C. J., 1983.† Organic films on atmospheric aerosol particles, fog droplets, cloud droplets, raindrops, and snowflakes. Rev. Geophys. Space Phys., in press.
- Gräedel, T. E. and Weschler, C. J., 1981.* Chemistry within aqueous atmospheric aerosols and raindrops. Rev. Geophys. Space Phys. **19**(4): 505-539.
- Haag, W. R. and Hoigné, J., 1983.* Ozonation of bromide-containing waters: Kinetics of formation of hypobromous acid and bromate. Environ. Sci. Technol. **17**: 261-267.
- Hansen, H. P., 1975.* Photochemical degradation of petroleum hydrocarbon surface films on seawater. Mar. Chem. **3**: 183-195.
- Hansen, H. P., 1977.* Photodegradation of hydrocarbon surface films. Rapp. P-v. Réunion. Cons. int. Explor. Mer **171**: 101-106.
- Hardy, J. T., 1982.* The sea surface microlayer: Biology, chemistry, and anthropogenic enrichment. Prog. Oceanog. **11**: 307-328.
- Hoigné, J. and Bader, H., 1979. Proc. 4th World Conf. Internat. Ozone Assoc., Houston, Texas.
- Hoigné, J. and Bader, H., 1979.† Ozonation of water: Selectivity and rate of oxidation of solutes. Ozone Sci. Eng. **1**: 73-85.

- Hoigné, J. and Bader, H., 1983.[†] Rate constants of reactions of ozone with organic and inorganic compounds in water. I: Nondissociating organic compounds. Water Res. 17: 173-183.
- Hoigné, J. and Bader, H., 1983.[†] Rate constants of reactions of ozone with organic and inorganic compounds in water. II: Dissociating organic compounds. Water Res. 17: 185-194.
- MacIntyre, P., 1974.^{*} The top millimeter of the ocean. Scient. Amer. 230: 62-77.
- Marty, J. C., Saliot, A., Buat-Menard, P., Chesselet, R. and Hunter, K. A., 1979.^{*} Relationship between the lipid compositions of marine aerosols, the sea surface microlayer, and subsurface water. J. Geophys. Res. 84: 5707-5716.
- Mill, T., 1979.[†] Structure Reactivity Correlations for Environmental Reactions. Environmental Protection Agency Final Report, No. EPA-560/11-79-012 (SRI Intern'l., Menlo Park, CA), 66 pp.
- Newman, L. (ed.), 1984.^{*} "Gas-Liquid Chemistry of Natural Waters," Vols. 1 and 2 (Brookhaven National Laboratory, Upton, N.Y.).
- Pilpel, N., 1975. Photo-oxidation of oil films sensitized by naphthalene derivatives. Inst. Pet., I.P. 75-007, 16 pp.
- Staehelin, J. and Hoigné, J., 1982.^{*} Decomposition of ozone in water: Rate of initiation by hydroxide ions and hydrogen peroxide. Environ. Sci. Technol. 16: 676-681.
- Staehelin, J. and Hoigné, J., 1983.[†] Reaction mechanism and kinetics of ozone decomposition in water in the presence of organic substances. Vom Wasser 61: 337-348.
- Thompson, A. M. and Zafirou, O. C., 1983.^{*} Air-sea fluxes of transient atmospheric species. J. Geophys. Res. 88: 6696-6708.
- Thompson, A. M. and Lenschow, D. H., 1984.^{*} Mean profiles of trace reactive species in the unpolluted marine surface layer. J. Geophys. Res. 89: 4788-4796.
- Wheeler, J., 1972.^{*} Some effects of solar levels of ultraviolet radiation on lipids in artificial sea water. J. Geophys. Res. 77: 5302-5306.

III. DIRECT PHOTOLYSIS - ORGANIC AND INORGANIC

- Adamson, A. W. and Fleischauer, P. D. (eds.), 1975.* "Concepts of Inorganic Photochemistry," Wiley-Interscience, N.Y., 439 pp.
- Akagi, H. and Takabatake, E., 1973.† Photochemical formation of methylmercuric compounds from mercuric acetate. Chemosphere 3: 131-133.
- Antia, N. J. and Landymore, A. F., 1974.* Physiological and ecological significance of the chemical instability of uric acid and related purines in sea water and marine algal culture medium. J. Fish. Res. Board Can. 31: 1327-1335.
- Barbier, M., Tusseau, D., Marty, J. C. and Saliot, A., 1981.* Sterols in aerosols, surface microlayer and subsurface water in the north-eastern tropical Atlantic. Oceanol. Acta 4(1): 77-84.
- Bunce, N. J., Kumar, Y. and Brownlee, B. G., 1978.* An assessment of the impact of solar degradation of polychlorinated biphenyls in the aquatic environment. Chemosphere 7: 155-164.
- Cairns-Smith, A. G., 1978.* Precambrian solution photochemistry, inverse segregation, and banded iron formations. Nature 276: 5690-5691.
- Carey, J. H. and Langford, C. H., 1973.* Photodecomposition of Fe(III) aminopolycarboxylates. Can. J. Chem. 51: 3665-3670.
- Carey, J. H. and Fox, M. E., 1981.† Photo degradation of the lampricide 3 tri fluoromethyl-4-nitro phenol. 1. Pathway of the direct photolysis in solution. J. Great Lakes Res. 7: 231-241.
- Carlucci, A. F., Silbernagel, S. B. and McNally, P. M., 1969.* Influence of temperature and solar radiation on persistence of vitamin B₁₂, thiamine, and biotin in seawater. J. Phycol. 5: 302-305.
- Collienue, R. H., 1983.* Photoreduction of iron in the epilimnion of acidic lakes. Limnol. Oceanogr. 28: 83-100.
- Crosby, D. G. and Tutass, H. O., 1966.† Photodecomposition of 2,4-dichlorophenoxyacetic acid. J. Agric. Food Chem. 14: 596-599.
- Crosby, D. G., Moilanen, K. W., Nakagawa, M. and Wong, A. S., 1972.† Photonucleophilic reactions of pesticides. In "Environmental Toxicology of Pesticides" (F. Matsumura, ed.), Academic Press, N.Y., pp. 423-433.

- Crosby, D. G. and Wong, A. S., 1973.[†] Photodecomposition of p-chlorophenoxyacetic acid. J. Agric. Food Chem. 21: 1049-1052.
- Crosby, D. G., 1983.[†] The fate of herbicides in California rice culture. In "Pesticide Chemistry: Human Welfare and Environment," Vol. 2 (J. Miyamoto and P. C. Kearney, eds.), Pergamon Press, Oxford, pp. 339-346.
- Crossland, N. O. and Wolff, C. J. M., 1984. Aquat. Toxicol. 4: in press.
- Ehrhardt, M., Bouchertall, F. and Hopf, H.-P., 1982.* Aromatic ketones concentrated from Baltic Sea water. Mar. Chem. 11: 449-461.
- Ertel, J. R., 1978.* The Fate of Phytol in the Sea Surface Microlayer. MS thesis, Florida State University.
- Faust, S. D., 1975.* Nonbiological degradation and transformations of organic pesticides in aqueous systems. In "Marine Chemistry in the Coastal Environment" (T. M. Church, ed.), A.C.S. Symp. Ser. 18. Am. Chem. Soc., Washington, D.C., pp. 572-595.
- Francko, D. A. and Heath, R. T., 1982.* UV-sensitive complex phosphorus: Association with dissolved humic material and iron in a bog lake. Limnol. Oceanogr. 27: 564-569.
- Francko, D. A. and Heath, R. T., 1983.* Abiotic uptake and photodependent release of phosphate from high-molecular weight humic-iron complexes in bog lakes. In "Aquatic and Terrestrial Humic Materials" (R. F. Christman and E. T. Gjessing, eds.), Ann Arbor Science, Ann Arbor, MI. Chapter 24, pp. 467-480.
- Goutz, M. and Saliot, A., 1980.* Relationship between dissolved and particulate fatty acids and hydrocarbons, chlorophyll a and zooplankton biomass in Villefranche Bay, Mediterranean Sea. Mar. Chem. 8: 299-318.
- Harvey, G. R., Boran, D. A., Chesal, L. A. and Tokar, J. M., 1983.* The structure of marine fulvic and humic acids. Marine Chem. 12: 119-132.
- Jewett, K. L., Brinckman, F. E. and Bellama, J. M., 1975.* Chemical factors influencing metal alkylation in water. In "Marine Chemistry in the Coastal Environment," (T. M. Church, ed.), A.C.S. Symp. Ser. 18. Am. Chem. Soc., Washington, D.C., pp. 304-318.
- Kamata, E., 1966.* Aldehydes in lake and sea waters. Bull. Chem. Soc. Jpn. 39: 1227-1229.
- Kennicutt, M. C. II and Jeffrey, L. M., 1981.* Chemical and GC-MS characterization of marine dissolved lipids. Marine Chem. 10: 367-387.

- Kennicutt, M. C. II and Jeffrey, L. M., 1981.* Chemical and GC-MS characterization of marine particulate lipids. Marine Chem. 10: 389-407.
- Landymore, A. F. and Antia, N. J., 1978.* White-light promoted degradation of leucopterin and related pteridines dissolved in seawater, with evidence for involvement of complexation from major divalent cations of seawater. Mar. Chem. 6: 309-325.
- Langford, C. H., Wingham, M. and Sastri, V. S., 1973.* Ligand photooxidation in copper(II) complexes of nitrilotriacetic acid. Implications for natural waters. Environ. Sci. Technol. 7: 820-822.
- Langford, C. H., Kay, R., Quance, Gay Win and Khan, T. R., 1977.† Kinetic analysis applied to iron in a natural water model containing ions, organic complexes, colloids, and particles. Anal. Lett. 10: 1249-1260.
- Lee, R. F. and Ryan, C., 1983.* Microbial and photochemical degradation of polycyclic aromatic hydrocarbons in estuarine waters and sediments. Canad. J. Fish. Aquat. Sci. 40(Suppl. 2): 86-94.
- Lockhart, H. B. Jr. and Blakeley, R. V., 1975.* Aerobic photodegradation of Fe(III)-(ethylenedinitrilo)tetraacetate (ferric EDTA). Implications for natural waters. Environ. Sci. Technol. 9: 1035-1031.
- Mabey, W. R., Tse, D., Baraze, A. and Mill, T., 1983.* Photolysis of nitroaromatics in aquatic systems. I. 2,4,6-trinitrotoluene. Chemosphere 12: 3-16.
- Macalady, D. L., Carpenter, J. H. and Moore, C. A., 1977.* Sunlight-induced bromate formation in chlorinated seawater. Science 195: 1335-1337.
- Mancini, J. L., 1978.* Analysis framework for photodecomposition in water. Environ. Sci. Technol. 12: 1274-1276.
- Mantoura, R. F. C., 1981.* Organo-metallic interactions in natural waters. In "Marine Organic Chemistry" (E. K. Duursma and R. Dawson, eds.), Elsevier, Amsterdam, pp. 179-223.
- McMahon, J. W., 1969.* The annual and diurnal variation in the vertical distribution of acid-soluble ferrous and total iron in a small dimictic lake. Limnol. Oceanogr. 14: 357-367.
- Mill, T., Hendry, D. G. and Richardson, H., 1980.* Free-radical oxidants in natural waters. Science 207: 886-887.

- Miille, M. J. and Crosby, D. G., 1983.* Pentachlorophenol and 3,4-dichloroaniline as models for photochemical reactions in seawater. Marine Chem. 14: 111-120.
- Miller, G. C. and Crosby, D. G., 1983.* Photooxidation of 4-chloroaniline and N-(4-chlorophenyl)-benzenesulfonamide to nitroso- and nitro-products. Chemosphere 12(9/10): 1217-1227.
- Natzle, W. C., Moore, C. B., Goodall, D. M., Frisch, W. and Holzwarth, J. F., 1981.* Dissociative ionization of water induced by single-photon vibrational excitation. J. Phys. Chem. 85: 2882-2884.
- Redden, G. D., 1982.* Characteristics of photochemical production of carbon monoxide in seawater. MS thesis in oceanography, Oregon State University, 108 pp.
- Rosen, J. D., 1971.* Photodecomposition of organic pesticides. In "Organic Compounds in Aquatic Environments" (S. J. Faust and J. V. Hunter, eds.), Marcel Dekker, N.Y., pp. 425-438.
- Ross, R. and Crosby, D. G., 1973.† Photolysis of ethylenethiourea. J. Agri. Food Chem. 21: 335-337.
- Ross, R. D. and Crosby, D. G., 1975.† The photooxidation of aldrin in water. Chemosphere 4: 277-282.
- Roubal, W. T., 1971.* Free radicals, malonaldehyde and protein damage in lipid-protein systems. Lipids 6: 62-64.
- Sauer, T. C., 1981.* Volatile organic compounds in open ocean and coastal surface waters. Org. Geochem. 3: 91-101.
- Sloper, R. W. and Land, E. J., 1980.* Photoinitiation of one electron reactions in dipeptides and proteins containing tryptophan and tyrosine. Photochem. Photobiol. 32: 687-689.
- Sunda, W. G., Huntsman, S. A. and Harvey, G. R., 1983.* Photoreduction of manganese oxides in seawater and its geochemical and biological implications. Nature 301: 234-236.
- Swallow, A. J., 1969. Hydrated electrons in seawater.* Nature 222: 369-370.
- Tanaka, F. S., Wien, R. G. and Hoffer, B. L., 1982.† Investigation of the mechanism and pathway of biphenyl formation in the photolysis of monuron. J. Agric. Food Chem. 30: 957-963.

- Trott, T., Henwood, R. W. and Langford, C. H., 1972.* Sunlight photochemistry of ferric nitrilotriacetate complexes. Environ. Sci. Technol. 6(4): 367-368.
- Volkman, J. K., Gatten, R. R. and Sargent, J. R., 1980.* Composition and origin of milky water in the North Sea. J. Mar. Biol. Assoc. U.K. 60: 759-768.
- Wagner, I., Strehlow, H. and Busse, G., 1980.* Flash photolysis of nitrate ions in aqueous solution. Zeit. für Phys. Chem N.F. 123: 1-33.
- Wilson, D. F., Swinnerton, J. W. and Lamontagne, R. A., 1970.* Production of carbon monoxide and gaseous hydrocarbons in seawater: Relation to dissolved organic carbon. Science 168: 1577-1579.
- Wolfe, N. L., Zepp, R. G., Baughman, G. L., Fincher, R. C. and Gordon, J. A., 1976.† Chemical and photochemical transformation of selected pesticides in aquatic systems. Environmental Protection Agency Final Report, No. EPA-600/3-76-067 (Environ. Res. Lab., Athens, GA), 153 pp.
- Wong, A. S. and Crosby, D. G., 1981.† Photodecomposition of pentachlorophenol in water. J. Agric. Food Chem. 29: 125-130.
- Zafiriou, O. C., 1974.* Sources and reactions of OH and daughter radicals in seawater. J. Geophys. Res. 79: 4491-4497.
- Zafiriou, O. C. and True, M. B., 1979.* Nitrite photolysis in seawater by sunlight. Mar. Chem. 8: 9-32
- Zafiriou, O. C. and True, M. B., 1979.* Nitrate photolysis in seawater by sunlight. Mar. Chem. 8: 33-42
- Zafiriou, O. C. and True, M. B., 1979.* Nitrite photolysis as a source of free radicals in productive surface waters. Geophys. Res. Lett. 6: 81-84.
- Zafiriou, O. C., McFarland, M. and Bromund, R. H., 1980.* Nitric oxide in seawater. Science 207: 637-639.
- Zafiriou, O. C. and McFarland, M., 1981.* Nitric oxide from nitrite photolysis in the central equatorial Pacific. J. Geophys. Res. 86(C4): 3173-3182.
- Zepp, R. G., Wolfe, N. L., Gordon, J. A. and Baughman, G. L., 1975.* Dynamics of 2,4-D esters in surface waters hydrolysis, photolysis, and vaporization. Environ. Sci. Technol. 9(13): 1144-1150.
- Zepp, R. G., Wolfe, N. L., Gordon, J. A. and Fincher, R. C., 1976.* Light-induced transformations of methoxychlor in aquatic systems. J. Agric. Food Chem. 24: 727-733.

- Zepp, R. G. and Cline, D. M., 1977.* Rates of direct photolysis in aquatic environment. Env. Sci. Tech. 11: 359-366.
- Zepp, R. G., 1978.* Quantum yields for reaction of pollutants in dilute aqueous solution. Env. Sci. Tech. 12(3): 327-329.
- Zepp, R. G. and Baughman, G. L., 1978.* Prediction of photochemical transformation of pollutants in the aquatic environment. In "Aquatic Pollutants: Transformations and Biological Effects" (O. Hutzinger, I. H. van Lelyveld and B. C. J. Zoeteman, eds.) Pergamon Press, Oxford, pp. 237-263.
- Zepp, R. G., Baughman, G. L. and Schlotzhauer, P. F., 1981.* Comparison of photochemical behaviour of various humic substances in water: I. Sunlight induced reactions of aquatic pollutants photosensitized by humic substances. Chemosphere 10: 109-117.

IV. HETEROGENEOUS PROCESSES

- Anderson, M. A. and Morel, F. M. M., 1982.* The influence of aqueous iron chemistry on the uptake of iron by the coastal diatom Thalassiosira weissflogii. Limnol. Oceanogr. 27: 789-813.
- Bard, A. J., 1979.† Photoelectrochemistry and heterogeneous photocatalysis at semiconductors. J. Photochem. 10: 59-75.
- Bard, A. J., 1982.* Design of semiconductor photoelectrochemical systems for solar energy conversion. J. Phys. Chem. 86: 172-177.
- Boehm, P. D. and Quinn, J. G., 1973.* Solubilization of hydrocarbons by the dissolved organic matter in sea water. Geochem. Cosmochim. Acta 37: 2459-2477.
- Botré, C., Memoli, A. and Alhaigue, F., 1978.* TCDD solubilization and photodecomposition in aqueous solutions. Environ. Sci. Technol. 12: 335-336.
- Calvin, M., 1980.* Synthetic chloroplasts. Faraday Discussions Chem., No. 70, pp. 383-402.
- Carey, J. H., Lawrence, J. and Tosine, H. M., 1976.* Photodechlorination of PCB's in the presence of titanium dioxide in aqueous suspensions. Bull. Environ. Contam. Toxicol. 16: 697-701.
- Carey, J. H. and Oliver, B. G., 1980.† The photochemical treatment of waste water by ultraviolet irradiation of semiconductors. Water Poll. Res. J. Canada 15: 157-185.
- Cerniglia, C. E. and Gibson, D. T., 1979.* Algal oxidation of aromatic hydrocarbons: Formation of 1-naphthol from naphthalene by Agmenellum quadruplicatum, strain PR-6. Biochem. Biophys. Res. Comm. 88: 50-58.
- Draper, W. M. and Crosby, D. G., 1983.* The photochemical generation of hydrogen peroxide in natural waters. Arch. Environ. Contam. Toxicol. 12: 121-126.
- Faraday Discussions, 1974.* Photo-effects in Adsorbed Species. Faraday Discussions, Chem. Soc., No. 58, 312 pp.
- Finklea, H. O., 1983.* Photoelectrochemistry: Introductory concepts. J. Chem. Ed. 60: 325-327.
- Fox, M. A., 1983.* Organic heterogeneous photocatalysis: Chemical conversions sensitized by irradiated semiconductors. Acc.Chem. Res. 16: 314-321.

- Gäb, S., Parlar, H., Nitz, S., Hustert, K. and Korte, F., 1974.[†] Ecological chemistry. LXXXI. Photochemical degradation of aldrin, dieldrin, and photodieldrin as solids in a current of oxygen. Chemosphere 3: 183-186.
- Gäb, S., Schmitzer, J., Thamm, H. W., Parlar, H. and Korte, F., 1977.^{*} Photomineralisation rate of organic compounds adsorbed on particulate matter. Nature 270: 331-333.
- Gerischer, H., 1977.[†] On the stability of semiconductor electrodes against photodecomposition. J. Electroanal. Chem. Interfacial Electrochem. 82: 133-143.
- Gerischer, H., 1978.[†] Electrolytic decomposition and photodecomposition of compound semiconductors in contact with electrolytes. J. Vac. Sci. Tech. 15: 1422-1428.
- Gerischer, H., 1980.^{*} Photodecomposition of semiconductors. Thermodynamics, kinetics and application to solar cells. Faraday Discussions Chem. Soc., No. 70, pp. 137-151.
- Goldberg, M. C. and Cunningham, K. M., 1983. Paper presented before the Division of Environmental Chem., Amer. Chem. Soc., Seattle, Wash., March-April, 1983.
- Grätzel, M., 1981.^{*} Artificial photosynthesis: Water cleavage into hydrogen and oxygen by visible light. Acc. Chem. Res. 14: 376-384.
- Hautala, R. R., 1978.[†] Surfactant effects on pesticide photochemistry in water and soil. Report EPA-600/3-78-060 (Environ. Res. Lab., Athens, GA), 83 pp.
- Herrmann, M., 19^{**} Photoinduced reactions of triazinone herbicides. Dissertation, München, Germany.
- Khenokh, M. A. and Bogdanova, N. P., 1968.[†] Doklady Akademii Nauk SSSR 182: 715-718.
- Kobayashi, H. and Rittmann, B. E., 1982.^{*} Microbial removal of hazardous organic compounds. Environ. Sci. Technol. 16: 170A-183A.
- Koenings, J. F., 1976.^{*} In situ experiments on the dissolved and colloidal state of iron in an acid bog lake. Limnol. Oceanogr. 21: 674-683.
- Kotzias, D., Klein, W., Lotz, F., Nitz, S. and Korte, F., 1979.^{*} Zur photoinduzierten mineralisierung organischer chemikalien. Chemosphere 5: 301-304.

- Krenske, D., Abdo, S., Van Damme, H., Cruz, M. and Fripiat, J. J., 1980.*
Photochemical and photocatalytic properties of adsorbed organometallic compounds. 1. Luminescence quenching of tris(2,2'-bipyridine)ruthenium(II) and -chromium(III) in clay membranes. J. Phys. Chem. **84**: 2447-2457.
- Lal, D., 1977.* The oceanic microcosm of particles. Science **198**: 997-1009.
- Langford, C. H., Kay, R., Quance, Gay Win and Khan, T. R., 1977.† Kinetic analysis applied to iron in a natural water model containing ions, organic complexes, colloids, and particles. Anal. Lett. **10**: 1249-1260.
- Lee, R. F. and Ryan, C., 1983.* Microbial and photochemical degradation of polycyclic aromatic hydrocarbons in estuarine waters and sediments. Canad. J. Fish. Aquat. Sci. **40**(Suppl. 2): 86-94.
- Leermakers, P. A. and Thomas, H. T., 1965.* Electronic spectra and photochemistry of adsorbed organic molecules. I. Spectra of ketones on silica gel. J. Amer. Chem. Soc. **87**: 1620-1622.
- Leermakers, P. A., Thomas, H. T., Weis, L. D. and James, F. C., 1966.* Spectra and photochemistry of molecules adsorbed on silica gel. IV. J. Am. Chem. Soc. **88**: 5075-5083.
- Mansour, M. and Parlar, H., 1978.† Gas chromatographic determination of several cyclodiene insecticides in the presence of polychlorinated biphenyls by photoisomerization reactions. J. Agric. Food Chem. **26**(2): 483-485.
- Matsumura, F. and Esaac, E. G., 1979.† Degradation of pesticides by algae and aquatic microorganisms. In "Pesticide and Xenobiotic Metabolism in Aquatic Organisms" (M. A. Q. Khan, J. J. Lech and J. J. Menn, eds.), Am. Chem. Soc. Symposium Series 99, Washington, D.C. Chapter 22, pp. 371-387.
- McGinnes, P. R., 1974.* The photodecomposition of polynuclear aromatic hydrocarbons in natural water systems. Ph.D. thesis, University of Illinois, Urbana-Champaign, 117 pp.
- Miller, G. C. and Zepp, R. G., 1979.* Effects of suspended sediments on photolysis rates of dissolved pollutants. Water Res. **13**: 453-459.
- Miller, G. C. and Zepp, R. G., 1979.* Photoreactivity of aquatic pollutants sorbed on suspended sediments. Environ. Sci. Technol. **13**: 860-863.
- Moser, J. and Grätzel, M., 1982.* Photoelectrochemistry with colloidal semiconductors; laser studies of halide oxidation in colloidal dispersions of TiO_2 and $\alpha\text{-Fe}_2\text{O}_3$. Helvetica Chimica Acta **65**: 1436-1444.

- Nozik, A. J., 1980.* Introductory lecture: Photoelectrochemistry. Faraday Discussions, Chem. Soc., No. 70, pp. 7-17.
- O'Kelley, J. C. and Deason, T. R., 1976.† Degradation of Pesticides by Algae. Environmental Protection Agency Final Report, No. EPA-600/3-76/022, (Environ. Res. Lab., Athens, GA), 51 pp.
- Oliver, B. G., Cosgrove, E. G. and Carey, J. H., 1979.* Effect of suspended sediments on the photolysis of organics in water. Environ. Sci. Technol. 13: 1075-1077.
- Parlar, H., 1980.** UV-Reactions of Cyclodiene-insecticides under Simulated Environmental Conditions." Habilitation, TU-Munich, Germany.
- Parsons, T. R., 1975.* Particulate organic carbon in the sea. In "Chemical Oceanography," Vol. 2, 2nd edition (J. P. Riley and G. Skirrow, eds.), Academic Press, N.Y., pp. 365-383.
- Plimmer, J. R., 1972.† Photochemistry of pesticides. Discussion of the influence of some environmental factors. In "Pesticide Chemistry," Proc. 2nd Int. Congr. Pestic. Chem. (A. S. Tahori, ed.), Gordon and Breach, N.Y., Vol. 6, pp. 47-76.
- Safe, S. and Hutzinger, O., 1971.* Polychlorinated biphenyls: photolysis of 2,4,6,2',4',6'-hexachlorobiphenyl. Nature 232: 641-642.
- Sancier, K. M. and Wise, H., 1981.* Photoassisted oxidation of organic material catalyzed by sand. Atmospheric Environment 15: 639-640.
- Schrauzer, G. N. and Guth, T. D., 1977.† Photolysis of water and photoreduction of nitrogen on titanium dioxide. J. Am. Chem. Soc. 99: 7189-7193.
- Shindo, H. and Huang, P. M., 1982.* Role of Mn(IV) oxide in abiotic formation of humic substances in the environment. Nature 298: 363-365.
- Sinel'nikov, V. E., 1976.* Characteristics of the decomposition of easily oxidized organic substances in shallow waters (model experiments). Tr. Inst. Biol. Vnutr. Vod. Akad. Nauk. USSR 33: 65-73.
- Skurlatov, Y. I., Zepp, R. G. and Baughman, G. L., 1983.† Photolysis rates of (2,4,5-trichlorophenoxy) acetic acid and 4-amino-3,5,6-trichloropicolinic acid in natural waters. J. Ag. Food Chem., 31: 1065-1071.
- SooHoo, J. B. and Kiefer, D. A., 1982.* Vertical distribution of phaeopigments--I. A simple grazing and photooxidative scheme for small particles. Deep Sea Res. 29: 1539-1551.

- SooHoo, J. B. and Kiefer, D. A., 1982.* Vertical distribution of phaeopigments--II. Rates of production and kinetics of photooxidation. Deep Sea Res. 29: 1553-1563.
- Sunda, W. G., Huntsman, S. A. and Harvey, G. R., 1983.* Photoreduction of manganese oxides in seawater and its geochemical and biological implications. Nature 301: 234-236.
- Tanaka, F. S., Wien, R. G. and Hoffer, B. L., 1982.† Investigation of the mechanism and pathway of biphenyl formation in the photolysis of monuron. J. Agric. Food Chem. 30: 957-963.
- Thomas, J. K., 1977.* Effect of structure and charge on radiation-induced reactions in micellar systems. Accts. Chem. Res. 10: 133-138.
- Waite, T. D., 1983.† Photoredox properties of iron in natural waters. Ph.D. thesis, Dept. Civil Engineering, R. M. Parsons Laboratory, Massachusetts Institute of Technology, 261 pp.
- Welschmeyer, N. A., 1982.† The dynamics of phytoplankton pigments: implications for zooplankton grazing and phytoplankton growth. Ph.D. dissertation, University of Washington, 187 pp.
- Wiessner, W., 1970.† Photometabolism of organic substrates. In "Photobiology of Microorganisms" (P. Halldal, ed.), Wiley Interscience, N.Y.
- Willner, I. and DeGani, Y., 1982.* Photoinduced electron transfer reactions as photosynthetic models: Reduction of anthraquinones in SiO_2 and ZrO_2 colloids. Israel J. Chem. 22: 163-167.
- Wright, S. L. J., 1978.† Interactions of pesticides with micro-algae. In "Pesticide Microbiology" (I. R. Hill and S. J. L. Wright, eds.), Academic Press, London, pp. 535-602.
- Wrighton, M. S., 1979.* Photoelectrochemical conversion of optical energy to electricity and fuels. Accts. Chem. Res. 12: 303-310.
- Zepp, R. G. and Schlotzhauer, P. F., 1983.** Influence of algae on photolysis rates of chemicals in water. Environ. Sci. Technol. 17: 462-468.
- Zsolnay, A., 1977.* Sorption of benzene on particulate material in sea water. Rapp. P.-v. Réun., Cons. int. Explor. Mer 171: 117-119.

V. HYDROGEN PEROXIDE, ORGANIC PEROXIDES, AND OZONE

- Bahnemann, D. and Hart, E. J., 1982.* Rate constants of the reaction of the hydrated electron and hydroxyl radical with ozone in aqueous solution. J. Phys. Chem. **86**: 252-255.
- Bühler, R., Staehelin, J. and Hoigné, J., 1984.** Ozone decomposition in water studied by pulse radiolysis. I: HO_4/O_2^- and HO_3/O_3^- as intermediates. J. Phys. Chem., **88**: 2560-2564.
- Chameides, W. L. and Davis, D., 1982.* The free radical chemistry of cloud droplets and its impact upon the composition of rain. J. Geophys. Res. **87**: 4863-4877.
- Cooper, W. J. and Zika, R. G., 1983.* Photochemical formation of hydrogen peroxide in surface and ground waters exposed to sunlight. Science **220**: 711-712.
- Garland, J. A., Elzerman, A. W. and Penkett, S. A., 1980.* The mechanism for dry deposition of ozone to seawater surfaces. J. Geophys. Res. **85**(C12): 7488-7492.
- Haag, W. R. and Hoigné, J., 1983.* Ozonation of bromide-containing waters: Kinetics of formation of hypobromous acid and bromate. Environ. Sci. Technol. **17**: 261-267.
- Hoigné, J. and Bader, H., 1976.* The role of hydroxyl radical reactions in ozonation processes in aqueous solutions. Water Res. **10**: 377-386.
- Hoigné, J. and Bader, H., 1978.† Ozonation and hydroxyl radical-initiated oxidations of organic and organometallic trace impurities in water. In "Organometals Organometalloids: Occurrence Fate Environ.," ACS Symp. Series No. 82, pp. 292-313.
- Hoigné, J. and Bader, H., 1979. Proc. 4th World Conf. Internat. Ozone Assoc., Houston, Texas.
- Hoigné, J. and Bader, H., 1979.† Ozonation of water: Selectivity and rate of oxidation of solutes. Ozone Sci. Eng. **1**: 73-85.
- Hoigné, J. and Bader, H., 1983.† Rate constants of reactions of ozone with organic and inorganic compounds in water. I: Nondissociating organic compounds. Water Res. **17**: 173-183.

- Hoigné, J. and Bader, H., 1983.[†] Rate constants of reactions of ozone with organic and inorganic compounds in water. II: Dissociating organic compounds. Water Res. 17: 185-194.
- Larson, R. A., Blankenship, D. W. and Hunt, L. L., 1976.* Toxic hydroperoxides: Photochemical formation from petroleum constituents. In "Sources, Effects & Sinks of Hydrocarbons in the Aquatic Environment," Proc. Symp. Am. Univ., Washington, DC, 9-11 Aug. 1976, pp. 298-308.
- Larson, R. A., Smykowski, K. and Hunt, L. L., 1981.* Occurrence and determination of organic oxidants in rivers and wastewaters. Chemosphere 10: 1335-1338.
- Mill, T., Hendry, D. G. and Richardson, H., 1980.* Free-radical oxidants in natural waters. Science 207: 886-887.
- Moffett, J. W. and Zika, R. G., 1983.* Oxidation kinetics of Cu(I) in seawater: Implications for its existence in the marine environment. Mar. Chem. 13: 239-251.
- Radding, S. B., Mill, T., Gould, C. W., Liu, D. H. and Johnson, H. L., 1976.[†] "The Environmental Fate of Selected Polynuclear Aromatic Hydrocarbons." Environmental Protection Agency Final Report, No. EPA/560/5-75-009 (Stanford Res. Inst., Menlo Park, CA), 131 pp.
- Sehested, K., Holcman, J. and Hart, E. J., 1983.* Rate constants and products of the reactions of e_{aq}^- , O_2^- , and H with ozone in aqueous solutions. J. Phys. Chem. 87: 1951-1954.
- Staehelin, J. and Hoigné, J., 1982.* Decomposition of ozone in water: Rate of initiation by hydroxide ions and hydrogen peroxide. Environ. Sci. Technol. 16: 676-681.
- Staehelin, J. and Hoigné, J., 1983.[†] Reaction mechanism and kinetics of ozone decomposition in water in the presence of organic substances. Vom Wasser 61: 337-348.
- Staehelin, J., Bühler, R. and Hoigné, J., 1984.** Ozone decomposition in water studied by pulse radiolysis. II: OH and HO_4 as chain intermediates. J. Phys. Chem., 88: 5999-6004.
- Stumm, W., 1978. What is the p^c of the sea? Thalassia Jugoslavica 14(1/2): 197-208.
- Swern, D. (ed.), 1971.[†] Organic peroxy acids as oxidizing agents. In "Organic Peroxides," Vol. 2 (Wiley-Interscience, N.Y.).

Van Baalen, C. and Marler, J. E., 1966.* Occurrence of hydrogen peroxide in sea water. Nature 211: 951.

Zika, R. G., 1977.* An investigation in marine photochemistry. Ph.D. thesis, Dalhousie University, Halifax, Nova Scotia.

VI. LIGHT AND UNDERWATER LIGHT

- Armstrong, F. A. J. and Boalch, G. T., 1961.* The ultra-violet absorption of sea water. J. Mar. Biol. Assoc. U.K. 41: 591-597.
- Baker, K. S., Smith, R. C. and Green, A. E. S., 1980.* Middle ultraviolet radiation reaching the ocean surface. Photochem. Photobiol. 32: 367-374.
- Baker, K. S. and Smith, R. C., 1982.* Bio-optical classification and model of natural waters. 2. Limnol. Oceanogr. 27(3): 500-509.
- Baker, K. S. and Smith, R. C., 1982.* Spectral irradiance penetration in natural waters. In "The Role of Solar Ultraviolet Radiation in Marine Ecosystems" (J. Calkins, ed.), Plenum Press, N.Y., pp. 233-246.
- Baker, K. S., Smith, R. C. and Green, A. E. S., 1982.* Middle ultraviolet irradiance at the ocean surface: Measurements and models. In "The Role of Solar Ultraviolet Radiation in Marine Ecosystems" (J. Calkins, ed.), Plenum Press, N.Y., pp. 79-91.
- Bricaud, A., Morel, A. and Prieur, L., 1981.* Absorption by dissolved organic matter of the sea (yellow substance) in the UV and visible domains. Limnol. Oceanogr. 26(1): 43-53.
- Brown, M., 1977.* Transmission spectroscopy examinations of natural waters. C. Ultraviolet spectral characteristics of the transition from terrestrial humus to marine yellow substance. Estuarine Coastal Mar. Sci. 5: 309-317.
- Calkins, J., 1982.* Measuring devices and dosage units. In "The Role of Solar Ultraviolet Radiation in Marine Ecosystems" (J. Calkins, ed.), Plenum Press, N.Y., pp. 169-179.
- CIAP, 1975.† Impacts of Climatic Change on the Biosphere. Monograph 5, Part 1. Ultraviolet Radiation Effects (Chapters 4-10). Department of Transportation, Washington, DC. PB-247 725/5.
- Di Toro, D. M., 1978.* Optics of turbid estuarine waters: approximations and applications. Water Res. 12: 1059-1068.
- Duursma, E. K., 1974.* The fluorescence of dissolved organic matter in the sea. In "Optical Aspects of Oceanography" (N. G. Jerlov and E. Steemann Nielsen, eds.), Academic Press, N.Y., pp. 237-256.
- Foster, P. and Foster, G. M., 1977.* Ultra-violet absorption characteristics of waters in an industrialized estuary. Water Res. 11: 351-354.

- Goldberg, B., 1982.* Radiometric measurements in the UV-B region of daylight. In "The Role of Solar Ultraviolet Radiation in Marine Ecosystems" (J. Calkins, ed.), Plenum Press, N.Y., pp. 121-129.
- Gordon, H. R., Brown, O. B. and Jacobs, M. M., 1975.* Computed relationships between the inherent and apparent optical properties of a flat homogeneous ocean. Applied Optics 14: 417-427.
- Green, A. E. S., Cross, K. R. and Smith, L. A., 1980.* Improved analytic characterization of ultraviolet skylight. Photochem. Photobiol. 31: 59-65.
- Hale, G. M. and Querry, M. R., 1973.* Optical constants of water in the 200 nm to 200 μ m wavelength region. Applied Optics 12: 555-563.
- Højerslev, N. K., 1971.* "Tyndall and Fluorescence Measurements in Danish and Norwegian Waters Related to Dynamical Features." Rept. No. 16 (Univ. of Copenhagen), 12 pp. plus tables + figures.
- Højerslev, N. K., 1974.* "Inherent and Apparent Optical Properties of the Baltic." Rept. No. 23 (Univ. of Copenhagen), 41 pp. + tables.
- Højerslev, N. K., 1974.* "Daylight Measurements for Photosynthetic Studies in the Western Mediterranean." Rept. No. 26 (Univ. of Copenhagen), 38 pp.
- Højerslev, N. K., 1975.* A spectral light absorption meter for measurements in the sea. Limnol. Oceanogr. 20: 1024-1034.
- Højerslev, N. K., 1977.* "Inherent and Apparent Optical Properties of Icelandic Waters 'Bjarni Saemundsson Overflow 73'." (ICES Overflow '73 Expedition Contribution No. 34). Rept. No. 33 (Univ. of Copenhagen), 63 pp.
- Højerslev, N. K., 1978. Inherent and apparent optical properties of the North Sea. Fladen Ground Experiment FLEX 76. In SFB (ed.), FLEX-Atlas, Hamburg.
- Højerslev, N. K., 1982.* Yellow substance in the sea. In "The Role of Solar Ultraviolet Radiation in Marine Ecosystems" (J. Calkins, ed.), Plenum Press, N.Y., pp. 263-281.
- Højerslev, N. K., 1984.* Fundamentals of the Solar Radiation Field in Air and Underwater. Report No. 47 (Københavns Universitet, Copenhagen), 32 pp.
- IAPO, 1964.† "Standard Terminology on Optics of the Sea", International Association of Physical Oceanography, Committee on Radiant Energy in the Sea, 5 pp.

- Jerlov, N. G., 1961.[†] Optical measurements in the Eastern North Atlantic ("Discovery II" Expedition of August and September 1959). Medd. Oceanogr. Inst., Gothenburg 30, 40 pp.
- Jerlov, N. G., 1968.* "Optical Oceanography," Elsevier Oceanography Series, Vol. 5 (Elsevier, Amsterdam), 194 pp.
- Jerlov, N. G., 1976.* "Marine Optics" (Elsevier Sci. Pub., N.Y.), 231 pp.
- Johnson, F. S., Mo, T. and Green, A. E. S., 1976.* Average latitudinal variation in ultraviolet radiation at the earth's surface. Photochem. Photobiol. 23: 179-188.
- Kalle, Von. K., 1938.* Zum Problem der Meereswasserfarbe. Ann. d. Hydrol. Mar. Mitt. 66: 1-13.
- Kalle, K., 1961.[†] What do we know about the "Gelbstoff"? In "Symposium on Radiant Energy in the Sea" (N. G. Jerlov, ed.), Union Géodésique et Géophysique Internationale Monograph No 10, pp. 59-62.
- Kalle, K., 1963.* Über das Verhalten und die Herkunft der in den Gewässern und in der Atmosphäre vorhandenen himmelblauen Fluoreszenz. Dtsch. Hydrogr. Z. 16: 153-166.
- Kishino, M., Booth, C. R. and Okami, N., 1984.* Underwater radiant energy absorbed by phytoplankton, detritus, dissolved organic matter, and pure water. Limnol. Oceanogr. 29(2): 340-349.
- Kononova, M. M., 1966. In "Soil Organic Matter, its Nature, its Role in Soil Formation and in Soil Fertility" 2nd ed. (Pergamon Press, Oxford), pp. 101, 104.
- Kullenberg, G. and Nygard, K., 1971.[†] "Fluorescence Measurements in the Sea." Univ. of Copenhagen, Inst. Phys. Oceanogr., Report No. 15.
- Kullenberg, G. E. B., 1977.* Observations of the mixing in the Baltic thermo- and halocline layers. Tellus 29: 572-587.
- Kullenberg, G., 1982.* Note on the role of vertical mixing in relation to effects of UV radiation on the marine environment. In "The Role of Solar Ultraviolet Radiation in Marine Ecosystems" (J. Calkins, ed.), Plenum Press, N.Y., pp. 283-292.
- Lenoble, J., 1956. L'absorption du rayonnement ultraviolet par les ions présents dans la mer. Rev. Opt. 35: 526.
- Lenoble, J., 1956.* Sur le rôle des principaux sels dans l'absorption ultraviolette de l'eau de mer. Compt. Rend. Acad. Sci. Paris 242: 806-808.

- Lundgren, B. and Højerslev, N. K., 1971. Daylight measurements in the Sargasso Sea--Results from the "DANA" Expedition, January-April 1966. Rep. Inst. Phys. Oceanogr., Univ. of Copenhagen, 14, 20 pp.
- Lundgren, B., 1976.* Spectral Transmittance Measurements in the Baltic. Inst. Phys. Oceanogr., Univ. of Copenhagen, Report No. 30, 38 pp.
- Morel, A. and Smith, R. C., 1982.* Terminology and units in optical oceanography. Mar. Geodesy 5(4): 335-349
- Nyquist, G., 1979. Investigation of some optical properties of sea water with special reference to lignin sulfonates and humic substances. Thesis Department of Analytical Marine Chemistry, Univ. of Göteborg, 200 pp.
- Patel, C. K. N. and Tam, A. C., 1979.* Optical absorption coefficients of water. Nature 280: 302-304.
- Preisendorfer, R. W., 1976.† "Hydrologic Optics. Vol. VI. Surface," Report No. NOAA-77050406 (NOAA, Honolulu, HI), 404 pp.
- Robinson, N. (ed.), 1966.* "Solar Radiation" (Elsevier, Amsterdam), 347 pp.
- Smith, R. C. and Tyler, J. E., 1976.† Transmission of solar radiation into natural waters. In "Photochemical and Photobiological Reviews," Vol. 1 (K. C. Smith, ed.), Plenum Press, N.Y., pp. 117-155.
- Smith, R. C. and Baker, K. S., 1978.* The bio-optical state of ocean waters and remote sensing. Limnol. Oceanogr. 23: 247-259.
- Smith, R. C. and Baker, K. S., 1979.* Penetration of UV-B and biologically effective dose-rates in natural waters. Photochem. Photobiol. 29: 311-323.
- Smith, R. C. and Baker, K. S., 1980.* Stratospheric ozone, middle ultra-violet radiation, and carbon-14 measurements of marine productivity. Science 208: 592-593.
- Smith, R. C. and Baker, K. S., 1981.* Optical properties of the clearest natural waters (200-800nm). Applied Optics 20: 177-184.
- Smith, R. C., Booth, C. R. and Star, J. L., 1984.* Oceanographic biooptical profiling system. Applied Optics 23(16): 2791-2797.
- Spitzer, D. and Wernand, M. R., 1981.* In situ measurements of absorption spectra in the sea. Deep Sea Res. 28A: 165-174.

- Yentsch, C. S. and Yentsch, C. M., 1982.* The attenuation of light by marine phytoplankton with specific reference to the absorption of near-UV radiation. In "The Role of Solar Ultraviolet Radiation in Marine Ecosystems" (J. Calkins, ed.), Plenum Press, N.Y., pp. 691-700.
- Zepp, R. G. and Schlotzhauer, P. F., 1981.* Comparison of photochemical behavior of various humic substances in water: III. Spectroscopic properties of humic substances. Chemosphere 10(5): 479-486.

VII. PETROLEUM

- Aaberg, A., Pedersen, D., Tjessem, K., 1984.[†] Factors affecting the extraction of polar environmental constituents from water. Water Res., in press.
- Barth, T., Tjessem, K. and Aaberg, A., 1981.^{*} Fractionation of polar organic constituents in environmental samples using the lipophilic dextran gels Sephadex LH-20 and Sephasorb HP ultrafine. J. Chromat. 214: 83-93.
- Berridge, S. A., Thew, M. T. and Loriston-Clarke, A. G., 1968. J. Inst. Petrol. 54: 333.
- Berridge, S. A., Dean, R. A., Fallows, R. G. and Fish, A., 1968. The properties of persistent oils at sea. J. Inst. Petrol. 54: 300-309.
- Boehm, P. D. and Quinn, J. G., 1973.^{*} Solubilization of hydrocarbons by the dissolved organic matter in sea water. Geochem. Cosmochim. Acta 37: 2459-2477.
- Burwood, R. and Spears, G. C., 1974. Photo-oxidation as a factor in the environmental dispersal of crude oil. Est. Coast. Mar. Sci. 2: 117-135.
- Calder, J. A., Lake, J. and Laseter, J., 1978. Chemical composition of selected environmental and petroleum samples from the AMOCO CADIZ oil spill. In "The AMOCO CADIZ Oil Spill, A Preliminary Scientific Report." NOAA/EPA Special Report.
- Carranza, Jorge.Mendez, D., 1983.^{**} Comportamiento de la producción pesquera del Golfo de México antes y después del derrame del Pozo IXTOC-I. Instituto Nacional de la Pesca.Secretaria de - Pesca.
- Clark, R. C. Jr. and MacLeod, W. D., 1977. In "Effects of Petroleum on Arctic and Subartic Marine Environments and Organisms," Vol. I (D. C. Malins, ed.), p. 129.
- Davenport, J., Lønning, S. and Saethre, L. J., 1979.^{*} The effects of Ekofisk oil extract upon oxygen uptake in eggs and larvae of the cod Gadus morhua L. Astarte 12: 31-34.
- Dowty, B. J., Brightwell, M. E., Laseter, J. L. and Griffin, G. W., 1974. Dye-sensitized photooxidation of phenanthrene. Biochem. Biophys. Res. Comm. 57(2): 452-455.
- Ehrhardt, M., Bouchertall, F. and Hopf, H.-P., 1982.^{*} Aromatic ketones concentrated from Baltic Sea water. Mar. Chem. 11: 449-461.

- Ehrhardt, M. and Petrick, G., 1984. Mar. Chem. 14: 47-58.
- E.N.C.B., 1982. ^{**} Impacto ambiental de la derrama del Pozo IXTOC-I sobre el zooplancton. I.P.N.
- Falk-Petersen, I.-B., Saethre, L. J. and Lönning, S., 1982. ^{*} Toxic effects of naphthalene and methylnaphthalenes on marine plankton organisms. Sarsia 67: 171-178.
- Frankenfeld, J. W., 1973. Factors governing the fate of oil at sea: Variations in the amounts and types of dissolved or dispersed materials during the weathering process. In "Proceedings of Joint Conference on Prevention and Control of Oil Spills" (American Petroleum Institute).
- Freearde, M., Hatchard, C. G. and Parker, C. A., 1971. Oil spilt at sea: Its identification, determination and ultimate fate. Laboratory Practice 20-4: 35-40.
- Gesser, H. D., Wildman, T. A. and Tewari, Y. B., 1977. ^{*} Photooxidation of n-hexadecane sensitized by xanthone. Environ. Sci. Technol. 11(6): 605-608.
- Hansen, H. P., 1975. ^{*} Photochemical degradation of petroleum hydrocarbon surface films on seawater. Mar. Chem. 3: 183-195.
- Hansen, H. P., 1977. ^{*} Photodegradation of hydrocarbon surface films. Rapp. P-v. Réunion. Cons. int. Explor. Mer 171: 101-106.
- INSTITUTO MEXICANO DEL PETROLEO, 1983. ^{**} Cuantificación de Hidrocarburos fósiles y metales pesados en agua y sedimentos. II Informe Ixtoc, in press.
- Klein, A. E. and Pilpel, N., 1974. The effects of artificial sunlight upon floating oils. Water Res. 8: 79-83.
- Klein, A. E. and Pilpel, N., 1974. Photo-oxidation of alkylbenzenes initiated by 1-naphthol. J. Chem. Soc.: Faraday Trans. 1, 70: 1250-1256.
- Kovats, E., 1958. ^{*} Gas-chromatographische charakterisierung organischer Verbindungen. Teil 1: Retentionsindices aliphatischer halogenide, alkohole, aldehyde und ketone. Helv. Chim. Acta 41 (No. 206): 1915-1932.
- Lacaze, J. C. and de Naide, O. Villedon, 1976. Influence of illumination on phytotoxicity of crude oil. Mar. Pollut. Bull. 7: 73-76.

- Larson, R. A., Blankenship, D. W. and Hunt, L. L., 1976.* Toxic hydroperoxides: Photochemical formation from petroleum constituents. In "Sources, Effects & Sinks of Hydrocarbons in the Aquatic Environment," Proc. Symp. Am. Univ., Washington, DC, 9-11 Aug. 1976, pp. 298-308.
- Larson, R. A., Hunt, L. L. and Blankenship, D. W., 1977. Formation of toxic products from a No. 2 fuel oil by photooxidation. Environ. Sci. Technol. 11(5): 492-496.
- Larson, R. A. and Hunt, L. L., 1978.* Photooxidation of a refined petroleum oil: Inhibition by β -carotene and role of singlet oxygen. Photochem. Photobiol. 28: 553-555.
- Larson, R. A., Bott, T. L., Hunt, L. L. and Rogenmuser, K., 1979.* Photooxidation products of a fuel oil and their antimicrobial activity. Environ. Sci. Technol. 13: 965-969.
- Licea, S., 1983.** Evaluación de los posibles efectos del derrame del Pozo IXTOC-I sobre las comunidades de fitoplancton y la producción primaria. Centro de Ciencias del Mar y -- Limnología. UNAM, in press.
- MacKay, G. D. M., McLeaon, A. Y., Betancourt, O. J. and Johnson, B. D., 1973. J. Inst. Petrol. 59: 164.
- Majewski, J., O'Brien, J. and Barry, E., 1974. A kinetic study of a fuel oil undergoing photochemical weathering. Environ. Letts. 7: 145-161.
- Mill, T., Mabey, W. R., Lan, B. Y. and Baraze, A., 1981.* Photolysis of polycyclic aromatic hydrocarbons in water. Chemosphere 10(11/12): 1281-1290.
- Miller, G. C. and Zepp, R. G., 1979.* Effects of suspended sediments on photolysis rates of dissolved pollutants. Water Res. 13: 453-459.
- Miller, G. C. and Zepp, R. G., 1979.* Photoreactivity of aquatic pollutants sorbed on suspended sediments. Environ. Sci. Technol. 13: 860-863.
- Murrieta, X. and Pérez, A., 1983.** Estimación del efecto del petróleo crudo del IXTOC-I y del dispersante sobre larvas, postlarvas, juveniles y adultos de camarón y adultos de ostión y pulpo por medio de biosensayos. Científica y Técnica. Universidad de Sonora.
- Neff, J. M., 1979.† "Polycyclic Aromatic Hydrocarbons in the Aquatic Environment: Sources, Fates and Biological Effects." Applied Science Publishers, London, 262 pp.

Overton, E. B., Laseter, J. L., Mascarella, W., Rashke, C., Noiry, I. and Farrington, J. W., 1980. Photochemical oxidation of IXTOC-I oil.

Researcher/Pierce IXTOC-I Symposium.

Patel, J. R., McFall, J. A., Griffin, G. W. and Laseter, J. L., 1978. Toxic photo-oxygenated products generated under environmental conditions from phenanthrene. E.P.A. Symposium on Carcinogenic Polynuclear Aromatic Hydrocarbons in the Marine Environment. Pensacola Beach, FL, August 14-18, 1978.

Patel, R. J., Overton, E. B. and Laseter, J. L., 1979. Environmental photooxidation of dibenzothiophenes following the AMOCO CADIZ oil spill. Chemosphere 8: 557-561.

Patton, J. S., Rigter, U. W., Boehm, P. D. and Feist, D. L., 1981. IXTOC-I oil spill: Flaking of surface mousse in the Gulf of Mexico. Nature 290: 235-238.

Payne, J., 1984.[†] Physical/chemical weathering of petroleum in the marine environment. Mar. Technol. Soc. Jour., in press.

Pilpel, N., 1975. Photo-oxidation of oil films sensitized by naphthalene derivatives. Inst. Pet., I.P. 75-007, 16 pp.

PROGRAMA COORDINADO DE ESTUDIOS ECOLOGICOS EN LA SONDA DE CAMPECHE, 1980.^{**}

Informe de los Trabajos realizados para el control del Pozo IXTOC-I, el combate del derrame de - petroleo y determinacion de sus efectos sobre el ambiente marino. I-III + 242 pp.

Salgado, M. and Sandoval, E., 1983.^{**} Estudios Oceanográficos de apoyo en la zona marina para evaluar el impacto ambiental del derrame del Pozo IXTOC-I. II Informe Ixtoc, in press.

Sivadier, H. O. and Mikolaj, P. O., 1973. Proceedings of the Joint EPA API USCG Conference on Prevention and Control of Oil Spills 13-15 March, 475.

Skjoldal, H. R., Dale, T., Haldorsen, H., Pengerud, B., Thingstad, T. F., Tjessem, K. and Aaberg, A., 1982. Oil pollution and plankton dynamics. I. Controlled ecosystem experiment during the 1980 spring bloom in Lindåspollene, Norway. Neth. J. Sea Res. 16: 511-523.

Solberg, T., Barth, T. and Westrheim, K., 1982.^{*} Effects of illuminated Ekofisk crude oil on yolksac larvae of cod (Gadus morhua L.). ICES CM 1982/E:58, 8 pp.

- Solberg, T., Tilseth, S., Mangor-Jensen, A., Serigstad, B. and Westrheim, K., 1982.* Effects of low levels of Ekofisk crude oil on eggs and yolksac larvae of cod (Gadus morhua L.). ICES CM 1982/E:60, 18 pp.
- Solberg, T., Tilseth, S., Serigstad, B. and Westrheim, K., 1982.* Effects of low levels of a heavy fraction of Ekofisk crude oil on eggs and yolksac larvae of cod (Gadus morhua L.). ICES CM 1982/E:59, 13 pp.
- Thronsdén, J., 1982. Oil pollution and plankton dynamics. III. Effects on flagellate communities in controlled ecosystem experiments in Lindaspollene, Norway, June 1980 and 1981. Sarsia 67: 163-169.
- Tjessem, K. and Aaberg, A., 1983.† Photochemical transformation and degradation of petroleum residues in the marine environment. Chemosphere 12(11/12): 1373-1394.
- Tjessem, K., Kobberstad, O., and Aaberg, A., 1983.* Photochemically induced interactions in Ekofisk crude oil. Chemosphere 12(11/12): 1395-1406.
- Tjessem, K., Pedersen, D. and Aaberg, A., 1984.* On the environmental fate of a dispersed Ekofisk crude oil in sea-immersed plastic columns. Water Res. 18(9): 1129-1136.
- Tjessem, K., Aaberg, A. and Kobberstad, O., 1984.† Chemical aspects of the water soluble material of Ekofisk crude oil under field and laboratory conditions. Toxicol. Environ. Chem. 7: 131-159.
- van den Heuvel, C. J. M., Steinberg, H. and de Boer, T. J., 1980.* Recueil Trav. Chim. Pays-Bas. 96: 157-159.
- Vázquez, A., 1982.** Cuantificación de hidrocarburos fósiles y metales pesados en sedimentos y organismos marinos de la Sonda de Campeche. Instituto de Ciencias del Mar y Limnología. UNAM.
- Villalobos, A., 1983.** Evaluación de los efectos del derrame del IXTOC-I, sobre la comunidad arrecifal de Veracruz, Ver. y - Campeche. U.A.M.
- Waldman, G. D., Fannelop, T. K. and Johnson, R. A., 1972. "Preprints 4th Annual Offshore Technology Conference," Paper OTC 1548.
- Yañez, A., 1983.** Análisis cuantitativo de la dinámica ambiental de la Laguna de Términos y de la Sonda de Campeche, y ecología y estructura de las comunidades de peces; interrelaciones estuario-plataforma y comparación peces-habitat. Centro de Ciencias del Mar y Limnología. UNAM.

- Yañez, A, 1983.** Analisis comparativo de las poblaciones de peces de la Sonda de Campeche y de la Laguna de Términos antes y - después del derrame petrolero del Pozo IXTOC-I. Centro de Ciencias del Mar y Limnología. UNAM.
- Yañez, A. and Day W. John, 1983.** Estudios ecológicos de la Laguna de Términos, Campeche, México, con referencia especial a los - especial a los recursos pesqueros y al impacto potencial del hombre. Inst. de Ciencias del Mar y Limnología. CONACyT.
- Yoshida, T. et al., 1981.* The application of field-ionization and field-desorption mass spectrometry to the analysis of coal-derived oil. Bull. Chem. Soc. Jpn. 54: 1171-1175.
- Zepp, R. G., Baughman, G. L. and Schlotzhauer, P. F., 1981.* Comparison of photochemical behaviour of various humic substances in water: I. Sunlight induced reactions of aquatic pollutants photosensitized by humic substances. Chemosphere 10: 109-117.

VIII. PHOTOBIOLOGICAL ASPECTS

- Anderson, M. A. and Morel, F. M. M., 1982.* The influence of aqueous iron chemistry on the uptake of iron by the coastal diatom Thalassiosira weissflogii. Limnol. Oceanogr. 27: 789-813.
- Autor, A. P. and Stevens, J. B., 1978.* Mechanism of oxygen detoxification in neonatal rat lung tissue. Photochem. Photobiol. 28: 775-780.
- Bailey, C. A., Neihof, R. A. and Tabor, P. S., 1983.* Inhibitory effect of solar radiation on amino acid uptake in Chesapeake Bay bacteria. Appl. Env. Microb. 46: 44-49.
- Bors, W., Saran, M., Lengfelder, E., Spöttl, R. and Michel, C., 1974.† The relevance of the superoxide anion radical in biological systems. Curr. Top. Radiat. Res. Q. 9: 247-309.
- Brateman, P. S., Cairns-Smith, A. G. and Sloper, R. W., 1984.* Photo-oxidation of iron(II) in water between pH 7.5 and 4.0. J. Chem. Soc. Dalton Trans., No. 7, pp. 1441-1445.
- Carlucci, A. F., Silbernagel, S. B. and McNally, P. M., 1969.* Influence of temperature and solar radiation on persistence of vitamin B₁₂, thiamine, and biotin in seawater. J. Phycol. 5: 302-305.
- Cerniglia, C. E. and Gibson, D. T., 1979.* Algal oxidation of aromatic hydrocarbons: Formation of 1-naphthol from naphthalene by Agmenellum quadruplicatum, strain PR-6. Biochem. Biophys. Res. Comm. 88: 50-58.
- CIAP, 1975.† Impacts of Climatic Change on the Biosphere. Monograph 5, Part 1. Ultraviolet Radiation Effects (Chapters 4-10). Department of Transportation, Washington, DC. PB-247 725/5.
- Cooper, W. J. and Zika, R. G., 1983.* Photochemical formation of hydrogen peroxide in surface and ground waters exposed to sunlight. Science 220: 711-712.
- Draper, W. M. and Crosby, D. G., 1983.* The photochemical generation of hydrogen peroxide in natural waters. Arch. Environ. Contam. Toxicol. 12: 121-126.
- Dring, M. J., 1981.* Chromatic adaptation of photosynthesis in benthic marine algae: An examination of its ecological significance using a theoretical model. Limnol. Oceanogr. 26: 271-284.

- Folsome, C. and Brittain, A., 1981.* Model protocells photochemically reduce carbonate to organic carbon. Nature 291: 482-484.
- Foot, C. S., 1976.† Photosensitized oxidation and singlet oxygen: Consequences in biological systems. In "Free Radicals in Biology," Vol. 2 (W. A. Pryor, ed.), Academic Press, N.Y., p. 85-133.
- Green, A. E. S. and Schippnick, P. F., 1982.* UV-B reaching the surface. In "The Role of Solar Ultraviolet Radiation in Marine Ecosystems" (J. Calkins, ed.), Plenum Press, N.Y., pp. 5-27
- Grigsby, P. and Calkins, J., 1980.* The inactivation of a natural population of coliform bacteria by sunlight. Photochem. Photobiol. 31: 291-294.
- Harris, G. P., 1978.* Photosynthesis, productivity and growth: The physiological ecology of phytoplankton. Archiv für Hydrobiologie (Beiheft 10), 171 pp.
- Hassan, H. M., Moustafa, H. and Fridovich, I., 1980.† Impermeability of the Escherichia coli cell envelope to superoxide radical. In "Biological and Clinical Aspects of Superoxide and Superoxide Dismutase" (W. H. and J. V. Bannister, eds.), Elsevier, Amsterdam, pp. 57-71.
- Jagger, J., 1981.* The expanding science of photobiology. Nature 289: 636-637.
- Johnston, R. B. Jr., Pabst, M. J. and Sasada, M., 1980.* The release of superoxide anion by macrophages and its relationship to phagocytic microbicidal activity. In "Biological and Clinical Aspects of Superoxide and Superoxide Dismutase" (W. H. and J. V. Bannister, eds.), Elsevier, Amsterdam, pp. 211-221.
- Jokiel, P. L., 1980.* Solar ultraviolet radiation and coral reef epifauna. Science 207: 1069-1071.
- Kobayashi, H. and Rittmann, B. E., 1982.* Microbial removal of hazardous organic compounds. Environ. Sci. Technol. 16: 170A-183A.
- Lipschultz, F., Zafiriu, O. C., Wofsy, S. C., McElroy, M. B., Valois, F. W. and Watson, S. W., 1981.* Production of NO and N₂O by soil nitrifying bacteria. Nature 294: 641-643.
- Look, S. A., Fenical, W., Van Engen, D. and Clardy, J., 1984.* Erythrolides: Unique marine diterpenoids interrelated by a naturally occurring Di- π -methane rearrangement. J. Am. Chem. Soc. 106: 5026-5027.

- Lorenzen, C. J., 1979.* Ultraviolet radiation and phytoplankton photosynthesis. Limnol. Oceanogr. 24: 1117-1120.
- Matsumura, F. and Esaac, E. G., 1979.† Degradation of pesticides by algae and aquatic microorganisms. In "Pesticide and Xenobiotic Metabolism in Aquatic Organisms" (M. A. Q. Khan, J. J. Lech and J. J. Menn, eds.), Am. Chem. Soc. Symposium Series 99, Washington, D.C. Chapter 22, pp. 371-387.
- Miles, C. J. and Brezonik, P. L., 1981.* Oxygen consumption in humic-colored waters by a photochemical ferrous-ferric catalytic cycle. Environ. Sci. Technol. 15(9): 1089-1095.
- Moffett, J. W. and Zika, R. G., 1983.* Oxidation kinetics of Cu(I) in seawater: Implications for its existence in the marine environment. Mar. Chem. 13: 239-251.
- Morel, F. M. M. and Morel-Laurens, N. M. L., 1983.* Trace metals and plankton in the oceans: Facts and speculations. In "Trace Metals in Sea Water" (C. S. Wong, E. Boyle, K. W. Bruland, J. D. Burton and E. D. Goldberg, eds.), NATO Conference Series #IV: Marine Chemistry, Plenum Press, N.Y., pp. 841-869.
- Morine, G. H. and Kuntz, R. R., 1981.* Observations of C-S and S-S bond cleavage in the photolysis of disulfides in solution. Photochem. Photobiol. 33: 1-5.
- O'Kelley, J. C. and Deason, T. R., 1976.† Degradation of Pesticides by Algae. Environmental Protection Agency Final Report, No. EPA-600/3-76/022, (Environ. Res. Lab., Athens, GA), 51 pp.
- Olson, R. J., 1981.* Differential photoinhibition of marine nitrifying bacteria: a possible mechanism for the formation of the primary nitrite maximum. J. Mar. Res. 39: 227-238.
- Peak, M. J. and Peak, J. G., 1982.* Lethal effects on biological systems caused by solar ultraviolet light: Molecular considerations. In "The Role of Solar Ultraviolet Radiation in Marine Ecosystems" (J. Calkins, ed.), Plenum Press, N.Y., pp. 325-336.
- Pryor, W. A. (ed.), 1976.* "Free Radicals in Biology," Vol. I, Academic Press, N.Y., 320 pp.
- Pryor, W. A. (ed.), 1976.* "Free Radicals in Biology," Vol. II, Academic Press, N.Y., 320 pp.

- Pryor, W. A. (ed.), 1977.* "Free Radicals in Biology," Vol. III, Academic Press, N.Y., 336 pp.
- Pryor, W. A., 1978.* The formation of free radicals and the consequences of their reactions in vivo. Photochem. Photobiol. 28: 787-801.
- Pryor, W. A. (ed.), 1980.* "Free Radicals in Biology," Vol. IV, Academic Press, N.Y., 384 pp.
- Pryor, W. A. (ed.), 1982.* "Free Radicals in Biology," Vol. V, Academic Press, N.Y., 304 pp.
- Ramabhadran, T. V. and Jagger, J., 1976.* Mechanism of growth delay induced in Escherichia coli by near ultraviolet radiation. Proc. Nat. Acad. Sci. USA 73: 59-63.
- Sinel'nikov, V. E., 1976.* Characteristics of the decomposition of easily oxidized organic substances in shallow waters (model experiments). Tr. Inst. Biol. Vnutr. Vod. Akad. Nauk. USSR 33: 65-73.
- Skurlatov, Y. I., Zepp, R. G. and Baughman, G. L., 1983.† Photolysis rates of (2,4,5-trichlorophenoxy) acetic acid and 4-amino-3,5,6-trichloropicolinic acid in natural waters. J. Ag. Food Chem., 31: 1065-1071.
- Sloper, R. W. and Land, E. J., 1980.* Photoinitiation of one electron reactions in dipeptides and proteins containing tryptophan and tyrosine. Photochem. Photobiol. 32: 687-689.
- Smith, R. C. and Baker, K. S., 1979.* Penetration of UV-B and biologically effective dose-rates in natural waters. Photochem. Photobiol. 29: 311-323.
- Smith, R. C. and Baker, K. S., 1980.* Stratospheric ozone, middle ultraviolet radiation, and carbon-14 measurements of marine productivity. Science 208: 592-593.
- Smith, R. C., Baker, K. S., Holm-Hansen, O. and Olson, R., 1980.* Photoinhibition of photosynthesis in natural waters. Photochem. Photobiol. 31: 585-592.
- Solberg, T., Barth, T. and Westheim, K., 1982.* Effects of illuminated Ekofisk crude oil on yolksac larvae of cod (Gadus morhua L.). ICES CM 1982/E:58, 8 pp.
- Stumm, W. and Morgan, J. J., 1981. "Aquatic Chemistry," 3rd edn., Wiley-Interscience, N.Y., pp. 463-469.

- Sunda, W. G., Huntsman, S. A. and Harvey, G. R., 1983.* Photoreduction of manganese oxides in seawater and its geochemical and biological implications. Nature 301: 234-236.
- Thomson, B. E., Worrest, R. C. and Van Dyke, H., 1980.* The growth response of an estuarine diatom (Melosira nummuloides [Dillw.] Ag.) to UV-B (290-230 nm) radiation. Estuaries 3(1): 69-72.
- Wiessner, W., 1970.† Photometabolism of organic substrates. In "Photobiology of Microorganisms" (P. Halldal, ed.), Wiley Interscience, N.Y.
- Worrest, R. C., Wolniakowski, K. U., Scott, J. D., Brooker, D. L., Thomson, B. E. and Van Dyke, H., 1981.* Sensitivity of marine phytoplankton to UV-B radiation: impact upon a model ecosystem. Photochem. Photobiol. 33: 223-227.
- Worrest, R. C., 1982.* Review of literature concerning the impact of UV-B radiation upon marine organisms. In "The Role of Solar Ultraviolet Radiation in Marine Ecosystems" (J. Calkins, ed.), Plenum Press, N.Y., pp. 429-457.
- Wright, S. L. J., 1978.† Interactions of pesticides with micro-algae. In "Pesticide Microbiology" (I. R. Hill and S. J. L. Wright, eds.), Academic Press, London, pp. 535-602.
- Zepp, R. G. and Schlotzhauer, P. F., 1983.** Influence of algae on photolysis rates of chemicals in water. Environ. Sci. Technol. 17: 462-468.
- Zigman, S., 1982.* Mechanisms of actions of longwave-UV on marine organisms. In "The Role of Solar Ultraviolet Radiation in Marine Ecosystems" (J. Calkins, ed.), Plenum Press, N.Y., pp. 347-356.

IX. RADICALS

- Allen, A. O. and Bielski, B. H. J., 1982.* Formation and Disappearance of Superoxide Radicals in Aqueous Solutions. In "Superoxide Dismutase," Vol. I (L. W. Oberley, ed.), CRC Press, Boca Raton, FL., pp. 125-141.
- Anbar, M., 1968.* Cavitation during impact of liquid on water: Geochemical implications. Science **161**: 1343-1344.
- Anbar, M., 1968.* Water and aqueous solutions. In "Fundamental Processes in Radiation Chemistry" (P. Ausloos, ed.), Wiley-Interscience, N.Y., Chap. 10, pp. 651-685.
- Atkinson, R., Lloyd, A. C. and Wines, L., 1982.* An updated chemical mechanism for hydrocarbon/ NO_x / SO_2 photooxidations suitable for inclusion in atmospheric simulation models. Atmospheric Environment. **16**: 1341-1355.
- Bahnemann, D. and Hart, E. J., 1982.* Rate constants of the reaction of the hydrated electron and hydroxyl radical with ozone in aqueous solution. J. Phys. Chem. **86**: 252-255.
- Baldwin, A. C., Barker, J. R., Golden, D. M. and Hendry, D. G., 1977.* Photochemical smog. Rate parameter estimates and computer simulations. J. Phys. Chem. **81**: 2483-2492.
- Benson, S. W., 1968.† "Thermochemical Kinetics; methods for the estimation of thermochemical data and rate parameters" (John Wiley and Sons, N.Y.), 223 pp.
- Bühler, R., Staehelin, J. and Hoigné, J., 1984.** Ozone decomposition in water studied by pulse radiolysis. I: HO_4/O_2^- and HO_3/O_3^- as intermediates. J. Phys. Chem., **88**: 2560-2564.
- Chameides, W. L. and Davis, D., 1982.* The free radical chemistry of cloud droplets and its impact upon the composition of rain. J. Geophys. Res. **87**: 4863-4877.
- Fallab, S., 1967.* Reactions with molecular oxygen. Angew. Chem. Internat. Edit. **6**(6): 496-507.
- Fornier de Violet, P., 1981.† Polyhalide radical anions as intermediates in chemistry. Rev. Chem. Intermediates **4**: 121-169.
- Fridovich, I., 1982.* Measuring the activity of superoxide dismutases: an embarrassment of riches. In "Superoxide Dismutase," Vol. I (L. W. Oberley, ed.), CRC Press, Boca Raton, FL, pp. 69-77.

- Gräedel, T. E. and Weschler, C. J., 1981.* Chemistry within aqueous atmospheric aerosols and raindrops. Rev. Geophys. Space Phys. 19(4): 505-539.
- Hassan, H. M., Moustafa, H. and Fridovich, I., 1980.† Impermeability of the *Escherichia coli* cell envelope to superoxide radical. In "Biological and Clinical Aspects of Superoxide and Superoxide Dismutase" (W. H. and J. V. Bannister, eds.), Elsevier, Amsterdam, pp. 57-71.
- Hendry, D. G., Mill, T., Piskiewicz, L., Howard, J. A. and Eigenmann, H. K., 1974.* A critical review of H-atom transfer in the liquid phase: chlorine atom, alkyl, trichloromethyl, alkoxy, and alkylperoxy radicals. J. Phys. Chem. Ref. Data 3: 937-978.
- Hoigné, J. and Bader, H., 1976.* The role of hydroxyl radical reactions in ozonation processes in aqueous solutions. Water Res. 10: 377-386.
- Hoigné, J. and Bader, H., 1978.† Ozone and hydroxyl radical-initiated oxidations of organic and organometallic trace impurities in water. In "Organometals Organometalloids: Occurrence Fate Environ.," ACS Symp. Series No. 82, pp. 292-313.
- Hoigné, J. and Bader, H., 1979. Proc. 4th World Conf. Internat. Ozone Assoc., Houston, Texas.
- Hoigné, J. and Bader, H., 1979.† Ozonation of water: Selectivity and rate of oxidation of solutes. Ozone Sci. Eng. 1: 73-85.
- Howard, A. J., Tait, J. C., Yamada, T. and Chenier, J. H. B., 1981.* A kinetic electron spin resonance study of the reaction of some oxy radicals with vanadyl acetylacetonate. Can. J. Chem. 59: 2184-2190.
- Janzen, E. G., 1971.* Spin trapping. Acc. Chem. Res. 4: 31-40.
- Kochi, J. K., ed., 1973.* "Free Radicals" (Wiley-Interscience, N.Y.), 713 pp.
- Kuzmin, V. A. and Chibisov, A. K., 1971.* One-electron photo-oxidation of inorganic anions by 9,10-anthraquinone-2,6-disulfonic acid in the triplet state. Chem. Comm. (The Jour. of the Chem. Soc., Section D) 23: 1559-1560.
- Larson, R. A. and Hufnagel, J. M. Jr., 1980.* Oxidative polymerization of dissolved phenols by soluble and insoluble inorganic species. Limnol. Oceanogr. 25(3): 505-512.
- Lockhart, H. B. Jr. and Blakeley, R. V., 1975.* Aerobic photodegradation of Fe(III)-(ethylenedinitrilo)tetraacetate (ferric EDTA). Implications for natural waters. Environ. Sci. Technol. 9: 1035-1031.

- McCracken, D. R. and Buxton, G. V., 1981.* Failure of Arrhenius equation for hydroxyl radical-bicarbonate ion reaction above 100°C. Nature 292: 439-441.
- Mill, T., Richardson, H. and Hendry, D. G., 1978.* Oxidation of organic compounds in aquatic systems: The free radical oxidation of cumene. In "Aquatic Pollutants: Transformation and Biological Effects" (O. Hutzinger, I. H. Van Lelyveld and B. C. J. Zoeteman, eds.), Proc. Second Internl. Symp. on Aquatic Pollutants, Amsterdam, The Netherlands, 26-28 September 1977, Pergamon Press, Oxford, pp. 223-236.
- Mill, T., 1979.† Structure Reactivity Correlations for Environmental Reactions. Environmental Protection Agency Final Report, No. EPA-560/11-79-012 (SRI Intern'l., Menlo Park, CA), 66 pp.
- Mill, T. and Hendry, D. G., 1980.† Kinetics and mechanisms of free radical oxidation of alkanes and olefins in the liquid phase. In "Comprehensive Chemical Kinetics," Vol. 16 (C. H. Bamford and C. F. H. Tipper, eds.), Elsevier, Amsterdam, pp. 1-87.
- Mill, T., Hendry, D. G. and Richardson, H., 1980.* Free-radical oxidants in natural waters. Science 207: 886-887.
- Moffett, J. W. and Zika, R. G., 1983.* Oxidation kinetics of Cu(I) in seawater: Implications for its existence in the marine environment. Mar. Chem. 13: 239-251.
- Pohlman, A. and Mill, T., 1983.** Free radical oxidation in water: the decomposition of azo-initiators and oxidation of p-cresol and p-isopropylphenol. J. Am. Chem. Soc. 105: 2133-2138.
- Porter, N. A., Weber, B. A., Weenen, H. and Khan, J. A., 1980.* Autoxidation of polyunsaturated lipids. Factors controlling the stereochemistry of product hydroperoxides. J. Am. Chem. Soc. 102: 5597-5601.
- Pryor, W. A., 1956. "Free Radicals" (McGraw-Hill Book Company, N.Y.).
- Pryor, W. A., 1978.* The formation of free radicals and the consequences of their reactions in vivo. Photochem. Photobiol. 28: 787-801.
- Pryor, W. A. (ed.), 1978.† "Organic Free Radicals," ACS Symposium Series 69 (Amer. Chem. Soc., Washington, D.C.), 471 pp.
- Scaiano, J. C. and Stewart, L. C., 1983.* Phenyl radical kinetics. J. Am. Chem. Soc. 105: 3609-3614.

- Sehested, K., Holcman, J. and Hart, E. J., 1983.* Rate constants and products of the reactions of e_{aq}^- , O_2^- , and H with ozone in aqueous solutions. J. Phys. Chem. 87: 1951-1954.
- Sehgal, C., Sutherland, R. G. and Verrall, R. E., 1980.* Optical spectra of sonoluminescence from transient and stable cavitation in water saturated with various gases. J. Phys. Chem. 84: 388-395.
- Singh, A., 1978.* Introduction: Interconversion of singlet oxygen and related species. Photochem. Photobiol. 28: 429-433.
- Sloper, R. W. and Land, E. J., 1980.* Photoinitiation of one electron reactions in dipeptides and proteins containing tryptophan and tyrosine. Photochem. Photobiol. 32: 687-689.
- Staehelin, J. and Hoigné, J., 1982.* Decomposition of ozone in water: Rate of initiation by hydroxide ions and hydrogen peroxide. Environ. Sci. Technol. 16: 676-681.
- Staehelin, J. and Hoigné, J., 1983.† Reaction mechanism and kinetics of ozone decomposition in water in the presence of organic substances. Vom Wasser 61: 337-348.
- Staehelin, J., Bühler, R. and Hoigné, J., 1984.** Ozone decomposition in water studied by pulse radiolysis. II: OH and HO_4 as chain intermediates. J. Phys. Chem., 88: 5999-6004.
- Suflita, J. M., Loll, M. J., Snipes, W. C. and Bollag, J.-M., 1981.* Electron spin resonance study of free radicals generated by a soil extract. Soil Sci. 131(3): 145-150.
- Swallow, A. J., 1969. Hydrated electrons in seawater.* Nature 222: 369-370.
- Thomas, J. K., 1977.* Effect of structure and charge on radiation-induced reactions in micellar systems. Accts. Chem. Res. 10: 133-138.
- Thompson, A. M. and Zafiriou, O. C., 1983.* Air-sea fluxes of transient atmospheric species. J. Geophys. Res. 88: 6696-6708.
- Thompson, A. M. and Lenschow, D. H., 1984.* Mean profiles of trace reactive species in the unpolluted marine surface layer. J. Geophys. Res. 89: 4788-4796.
- Trott, T., Henwood, R. W. and Langford, C. H., 1972.* Sunlight photochemistry of ferric nitrilotriacetate complexes. Environ. Sci. Technol. 6(4): 367-368.

- Walling, C., 1957.* "Free Radicals in Solution" (John Wiley and Sons, N.Y.), 631 pp.
- Zafiriou, O. C., 1974.* Sources and reactions of OH and daughter radicals in seawater. J. Geophys. Res. 79: 4491-4497.
- Zafiriou, O. C. and True, M. B., 1979.* Nitrite photolysis in seawater by sunlight. Mar. Chem. 8: 9-32
- Zafiriou, O. C. and True, M. B., 1979.* Nitrate photolysis in seawater by sunlight. Mar. Chem. 8: 33-42
- Zafiriou, O. C. and True, M. B., 1979.* Nitrite photolysis as a source of free radicals in productive surface waters. Geophys. Res. Lett. 6: 81-84.
- Zafiriou, O. C. and McFarland, M., 1980.* Determination of trace levels of nitric oxide in aqueous solution. Anal. Chem. 52: 1662-1667.
- Zafiriou, O. C., McFarland, M. and Bromund, R. H., 1980.* Nitric oxide in seawater. Science 207: 637-639.
- Zafiriou, O. C. and McFarland, M., 1981.* Nitric oxide from nitrite photolysis in the central equatorial Pacific. J. Geophys. Res. 86(C4): 3173-3182.
- Zepp, R. G., Wolfe, N. L., Baughman, G. L. and Hollis, R. C., 1977.* Singlet oxygen in natural waters. Nature 267: 421-423.

X. SINGLET OXYGEN

- Aubry, J. M., Rigaudy, J. and Cuong, N. K., 1981.* A water-soluble rubrene derivative: synthesis, properties and trapping of $^1\text{O}_2$ in aqueous solution. Photochem. Photobiol. **33**: 149-153.
- Baxter, R. M. and Carey, J. H., 1982.* Reactions of singlet oxygen in humic waters. Freshwater Biol. **12**: 285-292.
- Botsivali, M. and Evans, D. F., 1979.* A new trap for singlet oxygen in aqueous solution. J. Chem. Soc. Chem. Commun. **1979**: 1114-1116.
- Foote, C. S., 1976. Photosensitized oxidation and singlet oxygen: Consequences in biological systems. In "Free Radicals in Biology," Vol. 2 (W. A. Pryor, ed.), Academic Press, N.Y., p. 85-133.
- Gollnick, K., 1975.[†] Chemical aspects of photodynamic action in the presence of molecular oxygen. In "Radiations Research: Biomedical, Chemical and Physical Perspectives," Proceedings of the Fifth Intern'l. Congress of Radiation Research, Seattle, WA, July 1974 (O. F. Nygaard, H. I. Adler and W. K. Sinclair, eds.), Academic Press, N.Y., pp. 590-611.
- Gorman, A. A. and Rodgers, M. A. J., 1981.* Singlet molecular oxygen. Chem. Soc. Rev. **10**: 205-231.
- Haag, W. R., Hoigné, J., Gassman, E. and Braun, A., 1984.* Singlet oxygen in surface waters Part I: Furfuryl alcohol as a trapping agent. Chemosphere **13**(5/6): 631-640.
- Haag, W. R., Hoigné, J., Gassman, E. and Braun, A., 1984.* Singlet oxygen in surface waters Part II: Quantum yields of its production by some natural humic materials as a function of wavelength. Chemosphere **13**(5/6): 641-650.
- Joussot-Dubien, J. and Kadiri, A., 1970.* Photosensitized oxidation of ammonia by singlet oxygen in aqueous solution and in seawater. Nature **227**: 700-701.
- Kacher, M. L. and Foote, C. S., 1979.* Chemistry of singlet oxygen--XXVIII. Steric and electronic effects on the reactivity of sulfides with singlet oxygen. Photochem. Photobiol. **29**: 765-769.
- Kearns, D. R., 1971.* Physical and chemical properties of singlet molecular oxygen. Chem. Reviews **71**: 395-427.

- Matheson, I. B. C. and Lee, J. 1979.* Chemical reaction rates of amino acids with singlet oxygen. Photochem. Photobiol. 29: 879-881.
- Merkel, P. B. and Kearns, D. R., 1972.* Remarkable solvent effects on the lifetime of $^1\Delta_g$ oxygen. J. Am. Chem. Soc. 94: 1029-1030.
- Merkel, P. B., Nilsson, R. and Kearns, D. R., 1972.* Deuterium effects on singlet oxygen lifetimes in solutions. A new test of singlet oxygen reactions. J. Am. Chem. Soc. 94: 1030-1031.
- Momzikoff, A., Santus, R. and Giraud, M., 1983.* A study of the photosensitizing properties of seawater. Mar. Chem. 12: 1-14.
- Momzikoff, A., Giraud, M., Santus, R. and Valla, A., 1983.* Photocondensations de biomolécules en eau de mer synthétique. Comparisons avec des fractions isolées du film superficiel des océans. Compt. Rend. Acad. Sci. Paris. (II)297: 261-264.
- Rodgers, M. A. J. and Snowden, P. T., 1982.* Lifetime of $O_2(^1\Delta_g)$ in liquid water as determined by time-resolved infrared luminescence measurements. J. Am. Chem. Soc. 104: 5541-5543.
- Singh, A., 1978.* Introduction: Interconversion of singlet oxygen and related species. Photochem. Photobiol. 28: 429-433.
- Wolff, C. J. M., Halmans, M. T. H. and van der Hiejde, H. B., 1981.* The formation of singlet oxygen in surface waters. Chemosphere 10: 59-62.
- Zepp, R. G., Baughman, G. L. and Schlotzhauer, P. F., 1981.* Comparison of photochemical behaviour of various humic substances in water: I. Sunlight induced reactions of aquatic pollutants photosensitized by humic substances. Chemosphere 10: 109-117.

XI. UNKNOWN CHROMOPHORES, ENERGY TRANSFER

- Adhikari, M. and Hazra, G. C., 1976.* Humus-metal complex: Spectral studies. J. Indian Chem. Soc. 53: 513-515.
- Almgren, T., Josefsson, B. and Nyquist, G., 1975.* A fluorescence method for studies of spent sulfite liquor and humic substances in sea water. Anal. Chim. Acta 78: 411-422.
- Armstrong, F. A. J. and Boalch, G. T., 1961.* The ultra-violet absorption of sea water. J. Mar. Biol. Assoc. U.K. 41: 591-597.
- Aubry, J. M., Rigaudy, J. and Cuong, N. K., 1981.* A water-soluble rubrene derivative: synthesis, properties and trapping of $^1\text{O}_2$ in aqueous solution. Photochem. Photobiol. 33: 149-153.
- Banerjee, S. K., 1979.† Acidity, quotient values and metal retention power of humic acids of varying molecular weights. J. Indian Soc. Soil Sci. 27: 38-42.
- Baxter, R. M. and Carey, J. H., 1982.* Reactions of singlet oxygen in humic waters. Freshwater Biol. 12: 285-292.
- Bricaud, A., Morel, A. and Prieur, L., 1981.* Absorption by dissolved organic matter of the sea (yellow substance) in the UV and visible domains. Limnol. Oceanogr. 26(1): 43-53.
- Brown, M., 1977.* Transmission spectroscopy examinations of natural waters. C. Ultraviolet spectral characteristics of the transition from terrestrial humus to marine yellow substance. Estuarine Coastal Mar. Sci. 5: 309-317.
- Burton, J. D., 1983.* A comment on the behaviour of dissolved organic carbon during estuarine mixing. In "The Major Biogeochemical Cycles and Their Interactions" (B. Bolin and R. B. Cook, eds.), John Wiley & Sons, N.Y., pp. 408-410.
- Carlson, R. E. and Shapiro, J., 1981.* Dissolved humic substances: A major source of error in fluorometric analyses involving lake waters. Limnol. Oceanogr. 26: 785-790.
- Carlucci, A. F., Silbernagel, S. B. and McNally, P. M., 1969.* Influence of temperature and solar radiation on persistence of vitamin B₁₂, thiamine, and biotin in seawater. J. Phycol. 5: 302-305.

- Choudhry, G. G., 1981.[†] Humic substances. Part I: Structural aspects. Toxicol. Environ. Chem. 4: 209-260.
- Choudhry, G. G., 1981.[†] Humic substances. Part II: Photophysical, photochemical and free radical characteristics. Toxicol. Environ. Chem. 4: 261-295.
- Chen, Y., Senesi, N. and Schnitzer, M., 1977.* Information provided on humic substances by E_4/E_6 ratios. Soil Sci. Soc. Am. J. 41: 352-358.
- Christman, R. F. and Chassemi, M., 1966.* Chemical nature of organic color in water. J. Amer. Water Works Assoc. 58: 723-741.
- Christman, R. F., 1970.* Chemical structures of color producing organic substances in water. In "Symposium on Organic Matter in Natural Waters"--held at Univ. of Alaska, 2-4 Sept. 1968 (D. W. Hood, ed.), Institute of Marine Science, Univ. of Alaska, Occasional Publication No. 1, pp. 181-198.
- Conrad, R. and Seiler, W., 1980.* Photooxidative production and microbial consumption of carbon monoxide in seawater. FEMS Microbiology Letters 9: 61-64.
- Craigie, J. S. and McLachlan, J., 1964.* Excretion of colored ultraviolet-absorbing substances by marine algae. Can. J. Bot. 42: 23-33.
- Datta, C., Ghosh, K. and Mukherjee, S. K., 1971.* Fluorescence excitation spectra of different fractions of humus. J. Indian Chem. Soc. 48: 279-287.
- Duursma, E. K., 1965.* The dissolved organic constituents of sea water. In "Chemical Oceanography," Vol. 1, 1st edition (J. P. Riley and G. Skirrow, eds.), Academic Press, London, U.K., pp. 433-475.
- Duursma, E. K., 1974.* The fluorescence of dissolved organic matter in the sea. In "Optical Aspects of Oceanography" (N. G. Jerlov and E. Steemann Nielsen, eds.), Academic Press, N.Y., pp. 237-256.
- Folsome, C. and Brittain, A., 1981.* Model protocells photochemically reduce carbonate to organic carbon. Nature 291: 482-484.
- Foster, P. and Foster, G. M., 1977.* Ultra-violet absorption characteristics of waters in an industrialized estuary. Water Res. 11: 351-354.
- Francko, D. A. and Heath, R. T., 1982.* UV-sensitive complex phosphorus: Association with dissolved humic material and iron in a bog lake. Limnol. Oceanogr. 27: 564-569.

- Francko, D. A. and Heath, R. T., 1983.* Abiotic uptake and photodependent release of phosphate from high-molecular weight humic-iron complexes in bog lakes. In "Aquatic and Terrestrial Humic Materials" (R. F. Christman and E. T. Gjessing, eds.), Ann Arbor Science, Ann Arbor, MI. Chapter 24, pp. 467-480.
- Gagosian, R. B., 1977 and Stuermer, D. H., 1977.* The cycling of biogenic compounds and their diagenetically transformed products in seawater. Mar. Chem. 5: 605-632.
- Ghosh, K. and Schnitzer, M., 1980.† Fluorescence excitation spectra of humic substances. Can. J. Soil Sci. 60: 373-379.
- Gjessing, E. T. and Gjerdahl, T., 1970.† Influence of ultra-violet radiation on aquatic humus. Vatten 26: 144-145.
- Harvey, G. R., Boran, D. A., Chesal, L. A. and Tokar, J. M., 1983.* The structure of marine fulvic and humic acids. Marine Chem. 12: 119-132.
- Højerslev, N. K., 1971.* "Tyndall and Fluorescence Measurements in Danish and Norwegian Waters Related to Dynamical Features." Rept. No. 16 (Univ. of Copenhagen), 12 pp. plus tables + figures.
- Højerslev, N. K., 1974.* "Inherent and Apparent Optical Properties of the Baltic." Rept. No. 23 (Univ. of Copenhagen), 41 pp. + tables.
- Højerslev, N. K., 1974.* "Daylight Measurements for Photosynthetic Studies in the Western Mediterranean." Rept. No. 26 (Univ. of Copenhagen), 38 pp.
- Højerslev, N. K., 1977.* "Inherent and Apparent Optical Properties of Icelandic Waters 'Bjarni Saemundsson Overflow 73'." (ICES Overflow '73 Expedition Contribution No. 34). Rept. No. 33 (Univ. of Copenhagen), 63 pp.
- Højerslev, N. K., 1978. Inherent and apparent optical properties of the North Sea. Fladen Ground Experiment FLEX 76. In SFB (ed.), FLEX-Atlas, Hamburg.
- Højerslev, N. K., 1982.* Yellow substance in the sea. In "The Role of Solar Ultraviolet Radiation in Marine Ecosystems" (J. Calkins, ed.), Plenum Press, N.Y., pp. 263-281.
- IAPO, 1964.† "Standard Terminology on Optics of the Sea", International Association of Physical Oceanography, Committee on Radiant Energy in the Sea, 5 pp.

- Jerlov, N. G., 1961.[†] Optical measurements in the Eastern North Atlantic ("Discovery II" Expedition of August and September 1959). Medd. Oceanogr. Inst., Gothenburg 30, 40 pp.
- Joussot-Dubien, J. and Kadiri, A., 1970.* Photosensitized oxidation of ammonia by singlet oxygen in aqueous solution and in seawater. Nature 227: 700-701.
- Kalle, Von. K., 1938.* Zum Problem der Meereswasserfarbe. Ann. d. Hydrol. Mar. Mitt. 66: 1-13.
- Kalle, K., 1961.[†] What do we know about the "Gelbstoff"? In "Symposium on Radiant Energy in the Sea" (N. G. Jerlov, ed.), Union Géodésique et Géophysique Internationale Monograph No 10, pp. 59-62.
- Kalle, K., 1963.* Über das Verhalten und die Herkunft der in den Gewässern und in der Atmosphäre vorhandenen himmelblauen Fluoreszenz. Dtsch. Hydrogr. Z. 16: 153-166.
- Kerr, R. A. and Quinn, J. G., 1980.* Chemical comparison of dissolved organic matter isolated from different oceanic environments. Mar. Chem. 8: 217-229.
- Khailov, K. M., 1963.[†] Some unknown organic substances in sea water. Publ. for National Science Foundation by Consultants Bureau, Vol. 147, pp. 1355-1357. (Translation of Dokl. Akad. Nauk S.S.S.R.)
- Khairy, A. H., 1981.[†] Presence of humic substances in human feces. Erfahrungsheilkunde 30: 898-903.
- Khan, S. U. and Schnitzer, M., 1972.* The retention of hydrophobic compounds by humic acid. Geochim. Cosmochim. Acta 36: 745-754.
- Koenings, J. F., 1976.* In situ experiments on the dissolved and colloidal state of iron in an acid bog lake. Limnol. Oceanogr. 21: 674-683.
- Kononova, M. M., 1966. In "Soil Organic Matter, Its Nature, Its Role in Soil Formation and in Soil Fertility" 2nd ed. (Pergamon Press, Oxford), pp. 101, 104.
- Kullenberg, G. E. B., 1977.* Observations of the mixing in the Baltic thermo- and halocline layers. Tellus 29: 572-587.
- Kumada, K. and Hurst, H. M., 1967.* Green humic acid and its possible origin as a fungal metabolite. Nature 214: 631-633.

- Kuzmin, V. A. and Chibisov, A. K., 1971.* One-electron photo-oxidation of inorganic anions by 9,10-anthraquinone-2,6-disulfonic acid in the triplet state. Chem. Comm. (The Jour. of the Chem. Soc., Section D) 23: 1559-1560.
- Lagercrantz, C. and Yhland, M., 1963.* Photo-induced free radical reactions in the solutions of some tars and humic acids. Acta Chem. Scand. 17(5): 1299-1306.
- Larson, R. A. and Hunt, L. L., 1978.* Photooxidation of a refined petroleum oil: Inhibition by β -carotene and role of singlet oxygen. Photochem. Photobiol. 28: 553-555.
- Lawrence, J., 1980.* Semi-quantitative determination of fulvic acid, tannin and lignin in natural waters. Water Res. 14: 373-377.
- Leyden, D. E., Cronin, J. T. and Ellis, A. T., 1982.† The effect of naturally occurring organic materials upon the preconcentration of metal ions and upon their determination by spectrometry. Intern. J. Environ. Anal. Chem. 11: 105-115.
- Mantoura, R. F. C., 1981.* Organo-metallic interactions in natural waters. In "Marine Organic Chemistry" (E. K. Duursma and R. Dawson, eds.), Elsevier, Amsterdam, pp. 179-223.
- Miles, C. J. and Brezonik, P. L., 1981.* Oxygen consumption in humic-colored waters by a photochemical ferrous-ferric catalytic cycle. Environ. Sci. Technol. 15(9): 1089-1095.
- Mill, T., Richardson, H. and Hendry, D. G., 1978.* Oxidation of organic compounds in aquatic systems: The free radical oxidation of cumene. In "Aquatic Pollutants: Transformation and Biological Effects" (O. Hutzinger, I. H. Van Lelyveld and B. C. J. Zoeteman, eds.), Proc. Second Internl. Symp. on Aquatic Pollutants, Amsterdam, The Netherlands, 26-28 September 1977, Pergamon Press, Oxford, pp. 223-236.
- Momzikoff, A., Santus, R. and Giraud, M., 1983.* A study of the photosensitizing properties of seawater. Mar. Chem. 12: 1-14.
- Nyquist, G., 1979. Investigation of some optical properties of sea water with special reference to lignin sulfonates and humic substances. Thesis Department of Analytical Marine Chemistry, Univ. of Göteborg, 200 pp.
- Ogura, N., 1976.† Decomposition of organic matter in seawater. Chikyu Kagaku (Nippon Chikyu Kagakkai) 10: 19-22.

- Otsuki, A. and Hanya, T., 1972.* Production of dissolved organic matter from dead green algal cells. I. Aerobic microbial decomposition. Limnol. Oceanogr. 17: 248-257.
- Petrovic, P. and Vitorovic, D., 1981.* Study of the optical density of humic acids. Chem. Abstr., Vol. 95, No. 113987g.
- Redden, G. D., 1982.* Characteristics of photochemical production of carbon monoxide in seawater. MS thesis in oceanography, Oregon State University.
- Roemelt, P. M. and Seltz, W. R., 1982.* Fluorescence polarization studies of perylene-fulvic acid binding. Environ. Sci. Technol. 16: 613-616.
- Saar, R. A. and Weber, J. H., 1980.* Comparison of spectrofluorometry and ion-selective electrode potentiometry for determination of complexes between fulvic acid and heavy-metal ions. Anal. Chem. 52: 2095-2100.
- Schnitzer, M. and Khan, S. U., 1972.† "Humic Substances in the Environment" (Marcel Dekker, N.Y.), 327 pp.
- Schnitzer, M., 1979.† Humic substances: Chemistry and reactions. In "Soil Organic Matter," Vol. 8 (M. Schnitzer and S. U. Khan, eds.), Elsevier, Amsterdam, pp. 1-64.
- Seal, B. K., Roy, K. B. and Mukherjee, S. K., 1964.* Fluorescence emission spectra and structure of humic and fulvic acids. J. Indian Chem. Soc. 41: 212-214.
- Sieburth, J. McN., and Jensen, A., 1969.* Studies on algal substances in the sea. II. The formation of Gelbstoff (humic material) by exudates of phaeophyta. J. Exp. Mar. Biol. Ecol. 3: 275-289.
- Skopintsev, B. A., 1971.* Recent advances in the study of organic matter in oceans. Oceanology 11(6): 775-789.
- Slawinski, J., Puzyna, W. and Slawinska, D., 1978.* Chemiluminescence during photooxidation of melanins and soil humic acids arising from a singlet oxygen mechanism. Photochem. Photobiol. 28: 459-463.
- SooHoo, J. B. and Kiefer, D. A., 1982.* Vertical distribution of phaeopigments--I. A simple grazing and photooxidative scheme for small particles. Deep Sea Res. 29: 1539-1551.
- SooHoo, J. B. and Kiefer, D. A., 1982.* Vertical distribution of phaeopigments--II. Rates of production and kinetics of photooxidation. Deep Sea Res. 29: 1553-1563.

- Stewart, A. J. and Wetzel, R. G., 1981.* Dissolved humic materials: Photodegradation, sediment effects, and reactivity with phosphate and calcium carbonate precipitation. Arch. Hydrobiol. 92(3): 265-286.
- Stuermer, D. H., 1975.* The characterization of humic substances in seawater. Ph.D. thesis, MIT/WHOI Joint Program, 188 pp.
- Suflita, J. M., Loll, M. J., Snipes, W. C. and Bollag, J.-M., 1981.* Electron spin resonance study of free radicals generated by a soil extract. Soil Sci. 131(3): 145-150.
- Thurman, E. M., Wershaw, R. L., Malcolm, R. L. and Pinckney, D. J., 1982.* Molecular size of aquatic humic substances. Org. Geochem. 4: 27-35.
- Tsutsuki, K. and Kuwatsuka, S., 1979.[†] Chemical studies on soil humic acids. VII. pH-dependent nature of the ultraviolet and visible absorption spectra of humic acids. Soil Sci. Plant Nutr. (Tokyo) 25: 373-384.
- Tsutsuki, K. and Kuwatsuka, S., 1979.[†] Chemical studies on soil humic acids. VIII. Contribution of carbonyl groups to the ultraviolet and visible absorption spectra of humic acids. Soil Sci. Plant Nutr. (Tokyo) 25: 501-512.
- Usui, Y. and Kamogawa, K., 1974.* A standard system to determine the quantum yield of singlet oxygen formation in aqueous solution. Photochem. Photobiol. 19: 245-247.
- Usui, Y., Tsukada, M., and Nakamura, H., 1978.* Kinetic studies of photosensitized oxygenation by singlet oxygen in aqueous micellar solutions. Bull. Chem. Soc. Jpn. 51: 379-384.
- Underdown, A. W., Langford, C. H. and Gamble, D. S., 1981.[†] The fluorescence and visible absorbance of copper(II) and manganese(II) complexes of fulvic acid: The effect of metal ion loading. Can. J. Soil Sci. 61: 469-474.
- Varney, M. S., Mantoura, R. F. C., Whitfield, D. R. and Riley, J. P., 1983.* Potentiometric and conformational studies of the acid-base properties of fulvic acid from natural waters. In: "Trace Metals in Seawater" (C. S. Wong, J. D. Burton, K. Bruland and E. D. Goldberg, eds.), Plenum Press, N.Y., pp. 751-772.
- Wilkinson, F. and Brummer, J. G., 1981.* Rate constants for the decay and reactions of the lowest electronically excited singlet state of molecular oxygen in solution. J. Phys. Chem. Ref. Data 10: 809-999.

- Williams, G. H. (ed.), 1965.[†] "Advances in Free Radical Chemistry" Vol. 1, Academic Press, NY.
- Williams, G. H. (ed.), 1965.[†] "Advances in Free Radical Chemistry" Vol. 2, Academic Press, NY., 274 pp.
- Williams, G. H. (ed.), 1969.[†] "Advances in Free Radical Chemistry" Vol. 3, Academic Press, NY., 317 pp.
- Williams, P. M., Oeschger, H. and Kinney, P., 1969.* Natural radiocarbon activity of the dissolved organic carbon in the North-east Pacific Ocean. Nature 224: 256-258.
- Williams, G. H. (ed.), 1972.[†] "Advances in Free Radical Chemistry" Vol. 4, Academic Press, NY., 307 pp.
- Williams, G. H. (ed.), 1975.[†] "Advances in Free Radical Chemistry" Vol. 5, Academic Press, NY., 394 pp.
- Wilson, D. F., Swinnerton, J. W. and Lamontagne, R. A., 1970.* Production of carbon monoxide and gaseous hydrocarbons in seawater: Relation to dissolved organic carbon. Science 168: 1577-1579.
- Wolff, C. J. M., Halmans, M. T. H. and van der Hiejde, H. B., 1981.* The formation of singlet oxygen in surface waters. Chemosphere 10: 59-62.
- Young, R. H., Wehrly, K. and Martin, R. L., 1971.* Solvent effects in dye-sensitized photooxidation reactions. J. Am. Chem. Soc. 93: 5774-5779.
- Zepp, R. G., Wolfe, N. L., Baughman, G. L. and Hollis, R. C., 1977.* Singlet oxygen in natural waters. Nature 267: 421-423.
- Zepp, R. G., Baughman, G. L. and Schlotzhauer, P. F., 1981.* Comparison of photochemical behaviour of various humic substances in water: I. Sunlight induced reactions of aquatic pollutants photosensitized by humic substances. Chemosphere 10: 109-117.
- Zepp, R. G., Baughman, G. L. and Schlotzhauer, P. F., 1981.* Comparison of photochemical behavior of various humic substances in water: II. Photosensitized oxygenations. Chemosphere 10: 119-126.
- Zepp, R. G. and Schlotzhauer, P. F., 1981.* Comparison of photochemical behavior of various humic substances in water: III. Spectroscopic properties of humic substances. Chemosphere 10(5): 479-486.
- Zepp, R. G., Schlotzhauer, P. F. and Sink, R. M., 1985.** Photosensitized transformations involving electronic energy transfer in natural waters: Role of humic substances. Environ. Sci. Technol. 19: 462-468.